UNDERSTANDING INTERNATIONAL ENVIRONMENTAL SECURITY: A STRATEGIC MILITARY PERSPECTIVE

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November 2000

AEPI-IFP-1100A

Army Environmental Policy Institute

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **NOV 2000**	2. REPORT TYPE	3. DATES COVERED **00-00-2000 to 00-00-2000**

4. TITLE AND SUBTITLE **Understanding International Environmental Security: A Strategic Military Perspective**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Environmental Policy Institute ,101 Marietta Street, Suite 3120,Atlanta,GA,30303-2720**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**122**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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Understanding International Environmental Security: A Strategic Military Perspective

Colonel W. Chris King

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Environmental security (ES), viewed as a process for addressing environmental issues potentially affecting U.S. national security, has significant implications for national military defense.

This paper analyzes the concepts, threats and opportunities. It uses a five-step development: paint an overview of the significance of ES; examine the knotty problems of ES definition; provide a "primer" in lay terms of the cross-cutting population trends and scientifically based environmental issues of climate change, land use and water use; using a geographic information systems analysis approach, analyze the total complex and list proposed, appropriate military missions; and summarize the national security implications of ES issues with recommended actions.

Major conclusions are:

- ES must be a component of the overall national security mission.
- The Services have an important, though supporting, role in ES initiatives.
- The least stable parts of the world from an ES standpoint are areas of Central and North Africa, the western Pacific Islands, the Ganges River basin and parts of Central and South America.
- Regional threat analysis is most effectively conducted by the geographic Commanders in Chief.
- The Theater Engagement Planning (TEP) process is the appropriate vehicle for military ES mission planning.

ACKNOWLEDGMENTS

Many people were of great assistance in gathering data and assisting in the analysis of environmental security as it is being practiced within the Department of Defense today. Mr. Steve Hearne of the European Command was the first to offer assistance and provide a jump-start in this project. Mr. Bob Jarrett of the Army Environmental Policy Institute was a valuable resource in scoping the project and provided a detailed peer review. Special thanks go to Mr. Gary Vest, the DOD Principal Undersecretary of Defense for Environmental Security, for taking the time to share his great knowledge of the subject and providing most of the data concerning the relationship between the DOD environmental security program and the rest of the government. COL(R) Kurt Kratz of the DOD environmental security office was an important resource, materially in the literature review process and overall with his expertise. Bill Mackie of the Joint Staff was a great supporter of this effort, with both his ideals and his help in coordinating the data collection effort at the Pentagon. COL Mike Kelley and COL Eugene Palka of the United States Military Academy are acknowledged for their detailed and most professional reviews of the initial draft of this document. I began this work while I was a student at the Naval War College. Thanks to Dr. Jim Miskel and Dr. Charlie Neimeyer of the War College faculty for their support of the project and reviews of the early products of this research. Dr. Russ Harmon of the Army Research Office is acknowledged for his detailed review of the manuscript and overall support for the project. Thanks to Captain Dale Manry and Major Greg Fleming of the United States Military Academy for contributing their geographic information system and computer expertise to the development of the spatial analysis and final graphics in this paper. Finally, this manuscript might never have made it to publication without the expertise of Ms. Celine Allen. Her professionalism and attention to detail were invaluable in completing this project.

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EXECUTIVE SUMMARY

This paper addresses two key questions:

What is environmental security?

What is the military mission in environmental security and how should this mission be executed?

Environmental security is an ill-defined term that means different things to different groups of people. Even the Department of Defense (DOD) has no generally accepted definition for environmental security. DOD Directive Number 4715.1 is actually a list of programs and thus fails to truly define or give meaning to the term. In this paper, the following is used as a working definition: Environmental security is a process for responding, as part of the U.S. National Security Strategy, to those environmental issues having the potential to affect U.S. national security.

A risk-assessment approach was used to determine which environmental issues are or have the potential to become national security concerns. The issues specifically addressed in this paper are: global climate change (global warming, El Niño and La Niña, ozone depletion in the atmosphere); land use (deforestation, desertification, hazardous wastes); and water use (fresh water, oceans). Discussion of each topic includes an explanation—in lay terms—of the scientific basis for the problem and an overview of environmental and security impacts. Analysis of these critical environmental issues is preceded by an in-depth look at population growth trends. While population is not generally considered an "environmental" issue, studies have shown that a combination of population growth and resource depletion can lead to environmental resource scarcity, which is a cause or a contributing factor in most regional conflict.

The review of critical environmental security issues is followed by a strategic analysis of the national security implications of these issues. Analysis of the threat posed by environmental degradation indicates that (1) as a result of impacts on the most critical resources (croplands, forests, water, and fish), humans are threatened by loss of water and food and increased incidence of disease; (2) the greatest overall impacts from cumulative environmental change will occur in tropical countries, which are all economically developing countries; (3) global warming with its linkages to deforestation is the issue with the potential to cause

the greatest damage; and (4) issues related to water are major stress factors on human subsistence and economic development.

A geographic information systems (GIS) analysis was used to determine more precisely where environmental security problems and conflicts are likely to occur. In doing this analysis, it became clear that population is the controlling independent variable for all environmental security issues, and rate of natural increase is the best measure for correlating environmental impacts and areas of concern. (For example, it was determined that the highest rates of deforestation are occurring in countries with high population growth rates.) Geographic areas of greatest concern in terms of environmental security are: the Sahel and central regions of Africa; the island nations of the western Pacific; the East India/Bangladesh region; and isolated areas of Central and South America.

The paper then addresses the role of the military in environmental security. The military environmental security mission, as described in the National Military Strategy (NMS), is to support the National Security Strategy (NSS). International environmental security is primarily a diplomatic and political function of the Department of State. Many environmental security issues are not military responsibilities and, like other national security issues, require a coordinated effort of several agencies. Although the NSS recognizes the risks to national security posed by numerous environmental issues, there is at present neither a national-level strategic document addressing these risks nor a governmental structure for dealing with them.

Military support for the accomplishment of NSS environmental security goals is reflected in the NMS as “Shape, Respond, Prepare Now.” “Shape” includes promoting regional stability and preventing/reducing conflict and threats through actions that can prevent or, as much as possible, mitigate adverse impacts of environmental change. “Respond” entails smaller scale contingency operations where it has been determined that military capabilities are necessary to respond to a regional environmental security emergency in order to expedite reestablishment of peace and security or reduce human suffering. “Prepare Now” is manning, equipping, and resourcing for the missions of the future.

The analysis in this paper shows that most environmental security issues that could involve the military are likely to occur at the regional level; this means that primary activities will fall under the purview of the regional Commanders in Chief (CINCs). “Shape” should be addressed in the CINC theater engagement plan (TEP) process and “Respond” should be part of CINC operational contingency planning. “Prepare Now” must begin at the national policy level with a plan that can be supported by the DOD. While the paper presents a list of actions that can be undertaken by the military, it points out that, until an overarching plan is developed at the national level, the DOD will not have the guidance it needs to begin carrying out its supporting role.

A major challenge in developing an overarching plan is the fact that the answers to many questions relating to environmental security are uncertain. The issues are technically complex, there are many unknowns, and there is often a lack of consensus among experts. It is extremely difficult to quantify the future impacts of environmental change on U.S. security.

Nevertheless, certain things are clear. Unfettered human activities can damage our environment on a global scale. Whether or not one accepts as a reason for U.S. involvement this country's moral obligation, the bottom line is that isolationism in environmental protection is not achievable. It is not possible to separate our air from theirs, our water from theirs, or our health from "their diseases." Taking action will involve significant costs, but those costs will be cheaper than the costs of not addressing environmental security, soon.

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1. INTRODUCTION

What is environmental security?

What is the military mission in environmental security and how should this mission be executed?

Succinctly stated, these are the questions to be addressed in this paper. "Environmental security" is a term one now hears regularly bandied about by senior leaders involved in national security and defense affairs. Does this mean that environmental security is now an integral part of the way the United States conducts its national security business, or, as it often happens, is it a term of fashionable jargon enjoying its brief state of acceptance in defense culture?

Bernard Brodie, a noted scholar on war, in a speech at the Army Command and General Staff College once made a prophetic comment about the misuse of "jargon." He stated:

> It [jargon] gives us a sort of shorthand, wherein a mere phrase can convey a very considerable body of thought and mutual understanding, which is of course characteristic of specialized vocabularies in all sciences. The function of jargon is, to be sure, frequently abused by scholars who have forgotten how to write or think in English. [1]

Professor Brodie seems to have had a point in expressing this view before a military audience, and it was not to further their dislike of "academics." The military often use jargon without the requisite "mutual understanding" and this is specifically true in the case of the term "environmental security." During my years of military experience I have heard numerous senior Department of Defense officials make reference to environmental security, each obviously using the term in a different context. This doesn't mean that any of those senior officials were wrong, but reinforces the fact that environmental security means different things to different people and therefore must be employed with care. Chapter 2 will be devoted to sifting through the numerous definitions for environmental security available in military and academic writing today to formulate a definition of environmental security specific to the purpose of this study.

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[1] Bernard Brodie, "The Worth of Principles of War," a lecture delivered on 7 March 1957 at the U.S. Army Command and General Staff College, Fort Leavenworth, Kans.

The impetus for this project originated in a growing sense that there are dramatic human-induced changes occurring in our environment, changes that are adversely affecting the Earth today and which, left unabated, will seriously impact the safety and security of our world in the future. A burgeoning population and its demands for natural resources, renewable and non-renewable, is leading this assault on the environment. Some consider technology a co-conspirator in the degradation of the environment. Certainly technology has evolved to the point that it can do great harm; conversely, technology can also heal and mitigate. Within this context, the overarching theme for this paper becomes,

> *Environmental degradation and environmental resource scarcity are of such a magnitude that they can become, if they are not already, an issue of national security (military and non-military) for the United States.*

There are several ways to use this book, depending on the reader's specific interests in environmental security. The science of environmental security is discussed in Chapter 3, with the non-scientist military and security professional as the target audience. Chapter 3 would be a good starting point for anyone wanting an introduction to such key environmental issues as global warming, damage to the ozone layer, deforestation, and desertification. Readers versed in the basics of environmental security issues may wish to only scan the topics in Chapter 3. Chapter 4 uses a qualitative risk-based approach to analyze the security impacts of environmental issues on a macro scale. While acknowledging that there are many uncertain issues relating to the future impacts of human-induced environmental change, it highlights what appear to be the major potential impacts of the environment on international security. Chapter 5 shapes environmental security into a military perspective for the planner at the regional geographic Commander in Chief (CINC) level.

1.1 The Environment and Security

The subject of this study is not new, particularly for the academic community where the environmental movement began. Many of the eminent scientists who advanced our understanding of the earth's environment were also the "doomsayers" (as they were characterized in their time) who predicted catastrophic environmental consequences of human activities. An unfortunate sideline in the early work on environmental security was that, as the concept developed, it was couched in the old civics debate of whether the government should spend money on "guns or butter." Norman Myers, an early environmental security scholar, expressed this view well when in 1986 he wrote,

> Hence national security is not just about fighting forces and weaponry. It relates to watersheds, croplands, forests, genetic resources, climate and other factors that rarely figure in the minds of military experts and political leaders, but increasingly deserve, in their collectivity, to rank alongside military approaches as crucial in a nation's security. [2]

In hindsight, it certainly appears that Myers was dead on target, at least in identifying future environmental security issues. It is also understandable that military leaders did not embrace his concepts, considering Myers's view that reduced military spending was the appropriate source for environmental security funding.

Today, the environmental security debate flourishes among social and political science scholars who work to redefine security, define environmental security, and devise political and social responses to environmental scarcities. Within the forum developed at the Woodrow Wilson International Center for Scholars, organized as the Environmental Change and Security Project, debate and discussion continue. Thomas Homer-Dixon,[3] Marc Levy, and others have helped develop and focus the early work of Norman Myers[4] and other scholars into a coherent understanding of how environmental issues can/will impact security in the future. Debates center primarily on defining security and applying the political sciences to analyze how developing countries will respond to environmental stress factors. Although these debates and discussions raise many challenging social issues, it is not a goal of this report to enter into that fray.

Previous research does offer important inputs for this study, which is focused on advancing our understanding of what the military mission should be. This body of work is intended to be an aid in identifying which, if any, of our worldwide environmental responsibilities are security concerns, and therefore should be included in our National Security Strategy and extend into our National Military Strategy.

However, this analysis is complicated by the political and social dimensions of government. The overall lack of a worthy adversary for the U.S. in a world without an Iron Curtain and a Cold War has required the development of new perspectives. Because of these bigger picture problems, we struggle with identifying and prioritizing issues such as environmental security, which heretofore have been lesser concerns.

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[2] Norman Myers, "The Environmental Dimension to Security Issues," *The Environmentalist* (1986): 251.
[3] Thomas Homer-Dixon, *Environmental Scarcity and Global Security* (New York: Foreign Policy Association, 1993).
[4] Norman Myers, *Ultimate Security: The Environmental Basis of Political Stability* (New York: Norton, 1993).

Predicting global climate change is challenging, but the environmental debate pales in light of the rhetoric concerning the new balance of power and security threats emerging as the political geography of the world restructures itself, mostly at the point of a gun. Samuel Huntington in his best selling *The Clash of Civilizations and the Remaking of the World Order*,[5] offered a brief review of the prevailing theories explaining political changes in the world today and predicting changes that will take place in the future. This review was followed by a presentation of his own theory on the subject, which is that an increased threat of violence arises from conflicts between peoples with different cultures.

While discussion of these different theories of political science is outside the scope of this project, it is disappointing to note that neither Huntington's theory nor any of the other theories he reviewed overtly considers environmental degradation as a primary source of conflict. Many of the theories, the Sheer Chaos Paradigm for example, have underlying threads in a number of the environmental issues discussed in this paper, but these theories suggest that everything else in the world is going to be so awful that environmental chaos will be hardly noticeable.

Were we to accept the Huntington view, this would be a relatively short essay, since according to him none of the environmental issues have a security component. However, others,[6] including this author, disagree, convinced that environmental issues may soon be major sources of conflict in the world. Rodney White, in his *North, South, and the Environmental Crisis*,[7] sees environmental security issues in terms of global hemispheres. In his view, the sources of conflict are the cumulative impacts of the environmental issues exacerbated by population growth and poverty in the Southern Hemisphere. Vice President Gore, one of our most environmentally competent political leaders, is deeply concerned with the potential damage to world order being brought on by environmental degradation.[8] The literature is filled with predictions of conflict over environmental issues, but the most striking evidence is in the records of actual conflict.

In a recent study, James Lee identified 70 separate modern era conflicts rooted in environmental issues.[9] The record shows that, dating back to 2500 BC, water has truly been something people will fight over. Today, this trend continues. James Gleick has identified 17

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[5] Samuel Huntington, *The Clash of Civilizations and the Remaking of the World Order* (New York: Simon and Schuster, 1996).

[6] For example, Ambassador Richard Armitage, a senior U.S. diplomat and strategic analyst, specifically disagreed with Huntington's view on causes of insecurity and listed environmental concerns such as water scarcity as looming threats. 23 May 2000 lecture at the Naval War College.

[7] Rodney White, *North, South, and the Environmental Crisis* (Toronto: University of Toronto Press, 1993).

[8] Albert Gore, *Earth in Balance* (Boston: Houghton-Mifflin, 1992).

[9] James Lee, *Inventory of Conflict and Environment* (Atlanta, Ga.: AEPI, April 1999).

distinct incidents of armed conflict directly over access to water for human use in the period from 1945 to 1997.[10] There are many other works that support the existence of causal relationships between environmental issues and conflict, though the directness of the linkage is not often clear. An example of indirect linkage can be seen in issues relating to what the United Nations has characterized as "environmental refugees," people displaced by the combined effects of population growth, resource scarcity, and disease.[11] The military and security repercussions of refugee problems are amply documented in military after-action reports from Rwanda, Somalia, Ethiopia, and the Sudan.

As the magnitude and extent of such problems as deforestation and loss of arable land increase in the future, it is certainly plausible that these too could give rise to conflicts in many regions of the world, conflicts as serious as those documented by Gleick for water scarcity problems.

1.2 The Obligation of the United States

It is fairly clear that environmental degradation and resource scarcity are going to cause problems for many people in different places in the world, but how should the U.S. respond? One response could be that it is not our problem, because the U.S. possesses adequate resources and employs sound conservation measures. Another line of reasoning might contend that it is counter to our security to become involved, because use of any military capacity for international environmental security further hampers readiness and heaps more burden onto an already overtaxed military.

Why then should the U.S.—and specifically in terms of this study, the U.S. Armed Forces—become involved? There are three ways of approaching this question, each leading to the same conclusion. The three approaches are:

1. It is a moral requirement for the United States.

2. It is an obligation the U.S. has incurred.

3. Practical self-interest dictates it as the prudent action.

[10] Peter Gleick, *The World's Water* (Washington, D.C.: Island Press, 1998), 125-130.
[11] White, 96-97.

The first approach is based on the conviction that America is great because of its high ideals and moral commitment. America continues to send its troops into harm's way in cases where the primary rationale is a belief in the basic rights of all people. Actions in Kosovo, protecting the Kurds, and assisting refugees in Rwanda are examples of military actions primarily driven by our moral precepts. As will be shown in this study, environmental scarcity and degradation issues are at least as threatening to more of the innocent population of the world than the proliferation of landmines and AK-47s. This rationale has been well described by numerous scholars and in the final analysis is the overriding basis for the Vice President's call to action. It can be said that the first requirement of a superpower is that it be willing to act like one, to lead when the world has issues that require bringing people together.

No country in human history has ever so dominated the world in economic and military power as the United States today.[12] In its strength, the U.S. consumes vast quantities of the world's renewable and non-renewable resources and produces more waste than any country on earth. The Army teaches even the lowest ranks that maintaining a healthy living environment is important in protecting their own health and staying "fit to fight." By extension, maintenance of a healthy living environment in the rest of the world is essential to sustaining the American way of life. Because of its demand for resources and its production of waste, the U.S. has incurred an obligation to sustain the global environment that supplies the resources this country thrives on. The U.S. must participate in world efforts to reduce resource demands and adverse impacts on the world environment, and these actions should become components of U.S. environmental security strategy. This is the rationale behind the second approach.

The third approach reflects the pragmatist's view of the world, a view that sees international environmental security as being in our nation's best interest. The cost of cleaning up a mess is always higher than the cost of prevention. Trying to rebuild a denuded forest or restore a contaminated or depleted water supply are costly activities compared to educating people on sustainable development or on measures that can be taken to preserve water supplies. More directly related to the issues of this study, the cost of war resulting from environmental scarcity and degradation will be greater than many of the actions that can be undertaken to prevent conflict.

Whether viewing our responsibilities in terms of our position as a world power, or of our complicity in the crime of polluting the world environment, or even of pragmatic financial realities, one would reach the same conclusion: U.S. interests dictate that environmental security must be considered in national security policy making. In spite of the uncertainties

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[12] Richard Danzig, Secretary of the Navy, lecture given at the Navy War College, June 2000.

associated with many environmental issues, the body of evidence confirming that humans are adversely impacting the environment on a global scale is irrefutable. Depletion of stratospheric ozone and the destruction of the Aral Sea are just two examples of global or large-scale anthropogenically generated changes in the environment. Something must be done and—for any of the reasons given above, or for all of them—environmental security should be a part of the American political agenda.

1.3 "National Security Strategy" and "National Military Strategy"

The U.S. National Security Strategy (NSS) for a New Century is the blueprint for all governmental actions associated with national defense and thus is the basis for strategic planning for the military. One of the "important national interests" identified in the December, 1999 NSS is "protecting the global environment from severe harm."[13] In defining our humanitarian and other interests, "promoting sustainable development and environmental protection"[14] is listed. Further, many of the human issues identified in the NSS have root causes in environmental problems. One example is refugee flow, which is listed as an important national interest. Environmental degradation is increasingly a major cause of mass migration, leading to starvation, epidemic disease, and the civil unrest that makes refugees a security concern. Overall, the NSS now recognizes that environmental issues are a significant national security concern and that they must be incorporated into our plan for preserving American security.

The NSS is the guide for all segments of national government as they map out their activities in pursuit of peace and security for our country. Environmental security is one of several issues raised in the NSS requiring coordinated actions from many agencies and departments, including but not limited to the Department of Defense (DOD). At present, the DOD, the U.S. Environmental Protection Agency (USEPA), the Department of Energy (DOE), and the Department of State (DOS) informally coordinate environmental security issues. Working groups and workshops meet on occasion to develop the relationships necessary to accomplish the NSS environmental requirements, but these efforts suffer because of their low priority within individual organizations and the absence of an overall national leader.

[13] The White House, *A National Security Strategy for a New Century* (Washington, D.C., 1999), 1.
[14] Ibid., 2.

Within the DOD, the environmental protection component of the NSS is addressed under the title "environmental security." Offices have been established within the DOD and programs are organized under the Deputy Under Secretary of Defense for Environmental Security.

The NSS provides the baseline guidance for the National Military Strategy (NMS). It then follows that, in developing and implementing the NMS, the Chairman of the Joint Chiefs of Staff must consider the environmentally related requirements of the NSS. The current NMS does in fact incorporate environmental protection threats. In its analysis of the strategic environment, the NMS states that "environmental strains continue to cause instability and the potential for violence."[15] Further, in discussing transnational dangers, the NMS notes that "massive refuge flow and threats to the environment each have the potential to put U.S. interests at risk."[16]

The threat analysis sections of both the NSS and the NMS provide consistent approaches to defining the risks to national security posed by numerous environmental issues. However, as the NMS moves into its strategic planning sections, the "how to address" environmental issues is absent. Certainly the NMS is a "big picture" strategic document and cannot cover all details for every security concern, but it is clear that the NMS strategy of "Shape, Respond, and Prepare Now" should include specific environmental actions as part of its response to its own threat analysis.

Given that the use of military power is only one way of protecting national security, differences between the NSS and the NMS are to be expected. As stated in the NMS, "The military is a complementary element of national power that stands with the other instruments wielded by our government."[17] Diplomacy through the Department of State and economic leverage are just two examples of how other government activities can be brought to bear on security issues. With regard to environmental protection, certainly the actions of the USEPA can directly contribute to meeting the environmental goals established in the NSS.[18]

Full accomplishment of NSS environmental objectives is hindered by the lack of a coordinated plan at the national government level. This paper addresses primarily the military departments' responses, but many environmental security issues are not military responsibilities and other issues will require a coordinated effort of several agencies. While the DOD continues to provide leadership in coordinating with other agencies and at the same

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[15]Chairman, Joint Chiefs of Staff, *National Military Strategy* (Washington, D.C., 1997), 8.
[16] Ibid., 9.
[17] Ibid., 5.
[18] USEPA, *Environmental Security* (Washington, D.C., 1999).

time developing and implementing the plans and activities necessary to meet its assigned responsibilities within the NSS, there is neither a national-level strategic planning document nor, as mentioned earlier, and overall national leader. Chapter 4 will make a first attempt to identify the military and non-military responsibilities relating to environmental security issues and suggest a new governmental structure for environmental security operations.

1.4 A Risk-Assessment Approach

In the course of this paper it will become clear that our scientific ability to predict environmental consequences of anthropogenically induced change is somewhat less than our ability to predict next week's weather. Competent scientists can look at the same set of data and reach diametrically opposite conclusions. A case in point is global warming, alias the greenhouse effect, alias carbon dioxide pollution of the global environment.

While the concept of global warming will be explained in detail in Chapter 3, we can use it here as an example. It is simple enough to deduce that adding too much carbon dioxide to the air is a bad thing, which will produce specific consequences: i.e., the earth warms, the ice caps melt, and we create a water world. However, other factors enter in, such as the interactions of the carbon cycle, concurrent changes to the environment, and natural regulating mechanisms. The result is an extremely complex system that is very difficult to interpret. So, if one surveys the literature, one finds recognized scientists predicting warming, cooling, major climate changes, minor climate changes, and all points in between. As with nearly all issues to be examined in this report, there are facts known with certainty, there are data collected over a relatively short period of geologic time, and there is the current level of scientific understanding to analyze and interpret the information. In total, we are left with a range of ideas and alternative views of the future, each lacking the precision or certainty we desire.

Given the uncertainties and ambivalence characterizing the current understanding of human impact on the environment, meaningful research requires making some fundamental assumptions concerning the extent and magnitude of the impacts of anthropogenically induced change. The risk-assessment model that is often employed to quantify consequences of environmental contamination events provides a logical framework within which to conduct our analysis. According to this model, the total risk of an event is defined as:

$$\text{RISK} = \text{probability of the event occurring} \times \text{severity of the impact} \qquad (1\text{-}1)$$

A hypothetical example should help to illustrate the concept. Assume that each time a person rides in a car he or she is subjected to the risk of an injury. The probability of an injury can be expressed in several ways, including: (1) there is a 1/10,000 chance of an injury each time a person rides in a car, or (2) on average, a person will be injured once for each 100,000 miles he or she rides. These numbers would be based on statistical analysis of actual data generated through accident reporting.

For the second term in Equation 1-1, the severity of the accident must be expressed in quantitative terms. One way of expressing the severity of the injury might be: for each person injured in a car accident, 1 out of 100 people die. A person's total risk of dying in a car accident in this example is then:

$$\text{RISK} = (1/100{,}000) \times (1/100) = 1/10{,}000{,}000 \qquad (1\text{-}2)$$

Expressed in words, a person has a one in ten million chance of dying for each 100,000 miles of riding in a car. Risk, then, is the chance of occurrence multiplied by the magnitude of the consequence.

As demonstrated by this example, under uncertain conditions a risk-based approach provides an effective evaluative tool for predicting future consequences and can be particularly useful in comparing alternatives. Risk analysis suggests that either of two conditions can transform an environmental issue into a national security issue, these two conditions being either a high probability of occurrence or impacts so dire that every possible alternative of avoidance or mitigation should be considered. Applying this model to our global warming example, we can see that, while we have no good estimate for the probability of occurrence, it is generally recognized that potential impacts would be destabilizing on a worldwide basis and, therefore, prudence necessitates consideration of global warming as a national security issue. This is the approach that was taken in selecting the critical environmental issues that will be examined in this report.

1.5 Goals and Purpose of This Research

The goal of this work is to produce a document that meets standards for good academic research, which is to advance the body of understanding in environmental security, and also passes the common sense or utility test. Early research into the subject of environmental security quickly revealed that the needs for study fell into two general categories.

First was the need for a primer on environmental issues and how they relate to national security. A recent finding from a plenary session of several governmental agencies involved in environmental security studies listed an *environmental security primer* as essential to strengthening our national environmental security strategy. From the military perspective, the senior leadership must understand environmental security issues from both a scientific and a policy view. The target audience for this document is therefore the geographic Commanders in Chief (CINCs) and their staffs. In military environmental security activities, CINCs have important roles to play, although they each arrive in the position with vastly different levels of knowledge on the environmental security issues. This document, particularly Chapter 3, is intended to jump-start a commander's understanding of the subject.

The second contribution to be made by this study is *to begin the strategic analysis process for the military*. Following the risk model described above, issues can be analyzed on the basis of national, then military impacts. Chapter 4 includes an analysis of specific environmental issues that threaten stability and peace. This is followed by an assessment of those issues that are relevant to military activities or have solutions within the defense component of the government and a discussion of the specifics of the military's emerging environmental security mission.

As with everything that the military accomplishes, the key to success will be careful analysis and planning. Military planners and operators need support in defining issues, assessing potential concerns, and developing plans that best utilize military capabilities and experience. At the national level, the military response should fit into a larger plan designed to achieve the goals of the NSS. This research found no evidence of detailed environmental security planning, nor of planning integration at the NSS level. Comments in this paper relating to needs in national level planning are included only to the extent required to develop a context for military activities as one component of national security strategy.

There is much work to be done in achieving a final environmental security strategy for the nation and the DOD. This study offers the following contributions toward planning and executing this mission:

1. An overview of critical environmental issues to help educate our leadership on the scientific basis of the concepts. (Chapter 3)

2. An analysis of strategic options in military environmental security policy. This includes a threat assessment to identify the most critical issues, a global scale geographic analysis to highlight the regions of greatest concern, and a listing of proposed military environmental security missions. (Chapter 4)

3. Finally, a summary of the national security implications of environmental issues and recommendations for action. (Chapter 5)

Many readers will not be familiar with some units of measure and scientific terms that appear in this document. Appendix A provides a listing with explanations of commonly used units of environmental measure. Throughout the document, terms and abbreviations are defined at first use; expanded definitions and a listing of all abbreviations can be found in Appendix B.

2. ENVIRONMENTAL SECURITY DEFINED

Chapter 1 introduced Professor Bernard Brodie and his views concerning the misuse of jargon, along with this author's opinion that "environmental security" is an often misused and regularly misunderstood term in military culture today. There is ample evidence to support this view: 20+ definitions for environmental security are readily available in recent government publications.

The concept of environmental security seems to have originated with the early work of Norman Myers[1] and others who focused on environmental issues with the potential to impact international security or world peace. It has since evolved into a term applied to encompass a broad range of activities, the only common element being some form of the word "environment" in their title.

At the outset of this research it was assumed that senior military leaders understood the definition of environmental security, but lacked an understanding of the underlying scientific basis for the environmental issues. However, as this research progressed and many divergent definitions of environmental security emerged, it became evident that there is no generally accepted definition of environmental security within the Department of Defense (DOD).

The real proof of the existing confusion came from hearing the term "environmental security" used by our senior DOD officials. At the most recent U.S. Army Senior Environmental Leadership Conference held in March 2000, the term was used frequently, but each time in a different context and with a different meaning. For a three-star general active in managing the Army force structure, environmental security meant a force protection issue, keeping deployed forces safe from environmental hazards in their areas of operation. Another senior officer used the term in reference to garrison environmental health and safety programs, in the context of compliance with state and federal regulations. Within the 20+ definitions found in the literature, both of these generals were correct, though it would be difficult to ever be wrong given the broad range of definitions currently in use.

[1] Norman Myers, "The Environmental Dimension to Security Issues," *The Environmentalist* (1986): 251-57.

2.1 Existing Definitions of Environmental Security

A recent international study sponsored by the Army Environmental Policy Institute devoted specifically to defining environmental security formally documented the existing confusion,[2] but was not able to resolve the definition problem. One option considered early in this research was to devise a new term specific to the environmental requirements of the National Security Strategy and the National Military Strategy. Such an approach would decouple the important national security issues from the baggage of confusion now encumbering the term "environmental security." This approach was rejected, because common sense suggested that there is already enough jargon and, from a philosophical standpoint, generating a new term seemed counterproductive in any effort to reduce the confusion that has been created by military jargon.

This study, however, requires a clear working definition of the term "environmental security." In developing a working definition, various sources were consulted. Presented below are several definitions extracted from a number of these sources. The differences give some indication of the wide range of meanings associated with the term.

United States Environmental Protection Agency

> Environmental security is a process whereby solutions to environmental problems contribute to national security objectives. [3]

An Academically Inspired Definition

> Environmental security is the proactive minimization of anthropogenic threats to the functional integrity of the biosphere and thus to its interdependent human component.[4]

Army Environmental Policy Institute (AEPI) Study

The AEPI study did not develop a specific definition, but defined the key elements that would describe a state of environmental security as:

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[2] Jerome Glenn and others, *Defining Environmental Security: Implications for the U.S. Army* (Atlanta, Ga.: AEPI, 1998).
[3] USEPA, *Environmental Security* (Washington, D.C., 1999), 1.
[4] An interesting definition found in the literature without specific reference.

1. Public safety from environmental dangers caused by natural or human processes due to ignorance, accident, mismanagement, or design.
2. Amelioration of natural resource scarcity.
3. Maintenance of a healthy environment.
4. Amelioration of environmental degradation.
5. Prevention of social disorder and conflict (promotion of social stability). [5]

DOD Directive Number 4715.1, Environmental Security

The DOD official definition is actually a list of programs encompassed under the title "Environmental Security" and thus fails to truly define or give meaning to the term:

> Definitions: 2. Environmental Security. The environmental security program enhances readiness by institutionalizing the Department of Defense's environmental, safety, and occupational health awareness, making it an integral part of the Department's daily activities. Environmental security is comprised of restoration, compliance, conservation, pollution prevention, safety, occupational health, explosive safety, fire and emergency services, pest management, environmental security technology, and international activities which are explained, as follows:
>
> a. Restoration is identification, evaluation, containment, treatment, and/or removal of contamination so that it no longer poses a threat to public health and the environment.
>
> b. Compliance is meeting applicable statutory, Executive order, and regulatory standards for all environmental security functions, including FGS or the Overseas Environmental Baseline Guidance Document, as appropriate.
>
> c. Conservation is planned management, use, and protection; continued benefit for present and future generations; and prevention of exploitation, destruction, and/or neglect of natural and cultural resources.
>
> d. Pollution prevention is source reduction as defined in 42 U.S.C. 13101-13109 (reference [nn]), and other practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw ma-

[5] Glenn and others, 19.

terials, energy, water and other resources, or protection of natural resources by conservation.

e. Safety is a multifaceted program designed to prevent accidental loss of human and material resources, and protects the environment from the potentially damaging effects of DoD mishaps.

f. Occupational health protects personnel from health risks, and includes occupational medicine, illness and injury trend analysis, epidemiology, occupational health nursing, industrial hygiene, and radiological health.

g. Fire and emergency services enhance combat capability by preserving life and DoD property through fire suppression, fire prevention, fire protection engineering, and emergency responses.

h. Explosives safety protects personnel, property, and military equipment from unnecessary exposure to the hazards associated with DoD ammunition and explosives; and protects the environment from the potentially damaging effects of DoD ammunition and explosives.

i. Pest management is the prevention and control of disease vectors and pests that may adversely affect the DoD mission or military operations; the health and well-being of people; or structures, material, or property.

j. Environmental security technology consists of research, development, test and evaluation, and regulatory certification of innovative technologies responsive to user needs.

k. International environmental activities include bilateral or multilateral agreements, information exchanges, cooperative agreements, and specific actions; consistent with the responsibilities identified in subsection E.3. above to bring DoD resources to bear on international military-related environmental matters or otherwise appropriate in support of national defense policy interests. [6]

[6] DOD, *Environmental Security* (Directive Number 4715.1, February 1996).

2.2 A Working Definition for This Research

This paper uses the term "environmental security" in a much more restrictive manner than the DOD directive definition given above and applies it more specifically to international defense security issues than do the other definitions listed here, thus leaving this researcher in the uncomfortable position of needing to create yet another definition for environmental security. The definition presented below sets the boundary conditions for all the work that will follow and is NOT purported to be the final, inclusive definition of "environmental security."

With these caveats, the definition for environmental security as it is applied in this research is:

> Environmental security is a process for effectively responding to changing environmental conditions that have the potential to reduce peace and stability in the world and thus affect U.S. national security. U.S. environmental security involves accomplishment of the environmentally related actions specified in the National Security Strategy. Accomplishing U.S. national environmental security goals requires planning and execution of programs to prevent and/or mitigate anthropogenically induced adverse changes in the environment and minimize the impacts of the range of environmental disasters that could occur.

This definition focuses on meeting the established goals of the NSS, which should be the basis for all U.S. security planning, and specifically on the DOD responsibilities of the NSS. This DOD role should necessarily be a part of the National Military Strategy published by the Chairman of the Joint Chiefs of Staff. [7]

There are both positives and negatives associated with environmental security issues. Three negatives that immediately come to mind are global climate change producing catastrophic suffering, mass migrations of people searching for water and other scarce resources, and deforestation of irreplaceable tropical forests.

However, there are also positives, especially in terms of the military. One of the most promising elements of the current DOD environmental security program is the forging of cooperative relationships with other countries through the sharing of military environmental protection and management practices. Many of the most positive military exchanges with the

[7] Gary Vest, "DOD International Environmental Activities," *Federal Facilities Journal* (Spring, 1997): 8.

countries emerging from the former Soviet bloc have related to environmental issues. Such opportunities have a double benefit for the DOD, building better military-to-military bridges while directly affecting important strategic concerns, such as political stability, economic development, and peace.

Our task, as this research now proceeds, is to identify the most important environmental scarcity and degradation issues and then find the best ways to employ the military in addressing these issues.

3. ENVIRONMENTAL ISSUES AND THEIR IMPACTS ON NATIONAL SECURITY

This chapter provides an overview of critical environmental issues. It serves as a basis for the strategic analysis of the national security implications of these issues presented in the next chapter.

The term "critical environmental issues" reflects two realities:

1. there are more environmental issues than can be covered effectively in this study and, more fundamentally,

2. not all environmental issues are national security concerns.

The latter reality is simple enough, but actually deciding which environmental issues relate to national security is a challenging task. Conflict over scarce resources, water for example, is easily defined as a problem area. There is, however, a thread of logic that can perceive a threat in nearly every environmental issue, if not as a primary effect, certainly as a secondary or tertiary impact influencing national security. For example, as we see often in today's world, human suffering from floods, mud slides, drought, or any of a long list of calamities may cause the national command authority to select a military response as a component of our aid in times of international humanitarian crises. Although a natural disaster is not in itself a security issue, any use of military forces has national security implications. It impacts the readiness of the troops by depriving them of time to train for their war-fighting mission, in diversion of resources from training, by causing wear and tear of military equipment (particularly air transportation assets), and through numerous other spillover impacts.

The issues selected for this analysis are a compilation of environmental stresses identified in works published by the U.S. Environmental Protection Agency (USEPA),[1] the Army Environmental Policy Institute (AEPI),[2] and a variety of authors included in the bibliography. Note that population trends analyses are included here even though population has not generally been considered an environmental issue. Strong arguments are being made by specialists in the field of human geography that it should be so viewed, since humans are part of the

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[1] USEPA, *Environmental Security* (Washington, D.C., 1999).
[2] Jerome Glenn and others, *Defining Environmental Security: Implications for the U.S. Army* (Atlanta, Ga.: AEPI, 1998).

ecosystem. It is becoming increasingly clear that one cannot consider environmental security issues without concurrently examining population trends, particularly in a regional context. For example, consider the water scarcity issues in several regions of the U.S. Water scarcity is caused by pollution of existing sources, reduction of available supplies, or increases in demand from either per capita demand increase or more people consuming at the same rate. In reality, most cases of regional water scarcity result from all of these factors occurring at the same time. Clearly, then, population trends must be examined in predicting water demand and determining scarcity issues.

Because population trends are an important variable in nearly all environmental security issues, we will begin this analysis by discussing population trends on a regional scale. We will then proceed to consider three major environmental areas:

- Global Climate Change
  - Global Warming (the greenhouse effect, greenhouse gases, the carbon cycle)
  - El Niño / La Niña
  - Ozone Depletion in the Stratosphere
- Land Use
  - Deforestation
  - Desertification
  - Hazardous Wastes
- Water Use
  - Fresh Water
  - Oceans

3.1 Population

Figure 3-1 depicts the increase in the human population of the Earth over the last 250 years and adds projections for the trends until the year 2100.[3] Clearly, an increasing population will have environmental impacts. We can use the concept of "carrying capacity" to help focus our understanding of the fundamental interrelationship between overpopulation and environmental security. Ecology and environmental geography share the concept of carrying capacity, which, defined in general terms, is the total population that the resources of an area can support over an indefinite period of time.[4]

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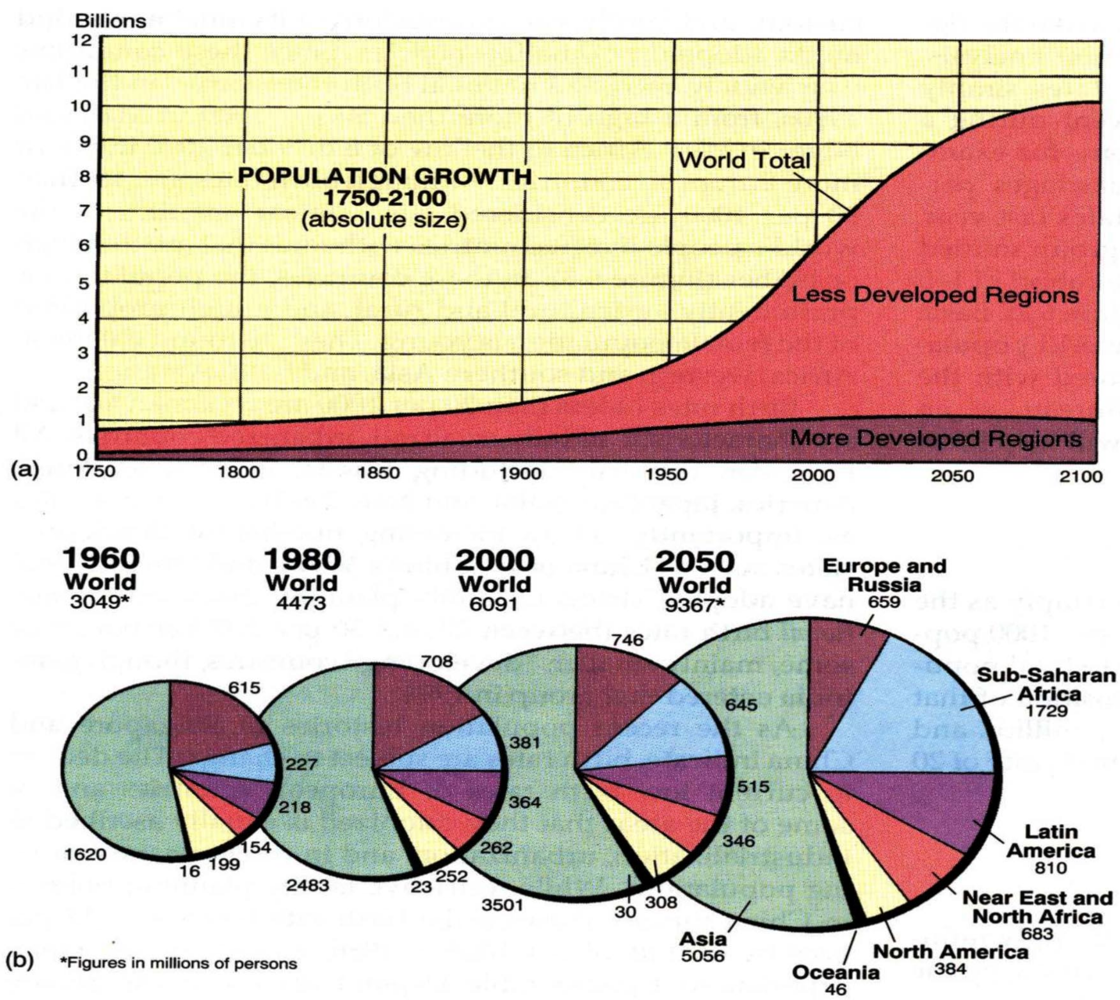
[3] Arthur Getis and others, *Introduction to Geography* (Boston: McGraw-Hill, 1998), 192.
[4] Ibid., 217.

The concept of carrying capacity is readily reflected in livestock management practices. Ranchers understand that a grazing area can sustain only a certain number of cattle or sheep per acre without long-term damage to the supporting vegetation. In the context of a specific geographical region, carrying capacity is a function of the soils, the climate, the availability of water, and several other natural system variables. The magnitude of carrying capacity can be influenced positively by technology with irrigation and fertilization, and it can also be impacted in both directions by weather, such as drought or increased rainfall. Over the long term, however, *only a finite number of animals* can be supported without damaging the land's ability to sustain its natural state.

FIGURE 3 – 1
World Populations, 1750–2100



SOURCE: Arthur Getis and others, *Introduction to Geography* (Boston: McGraw-Hill, 1998), 142.

From a human perspective, this principle is equally valid—even with the marvelous products of human ingenuity. Technology can change the relative value of human carrying capacity by enabling us to resource one region at the expense of another, changing efficiency of use, and providing solutions to many other specific problems. However, there are finite limits to the number of people any region can support and, by extension, the total population the entire world can support.[5] Some of the more academic philosophies of human activity espouse the belief that technology can overcome the fundamentals of carrying capacity; to date this belief has not proven valid. The critical resources of water and energy[6] are renewable at finite rates, which humankind can impact only in minor percentages of total use. In the final analysis, we remain one of the more fragile organisms on the planet, bound to a relatively constrained set of environmental conditions of landscape, temperature, oxygen, moisture, and available energy sources.

3.1.1 Population Issues

When one considers the concept of carrying capacity in the context of Figure 3-1, the question immediately arises: what is the total carrying capacity of the Earth? Figure 3-1 predicts a steady-state world population of slightly over 11 billion people by 2100, nearly double the current world population. Will the Earth be able to sustain this many people?

We cannot even attempt to answer the questions without first considering the spatial distribution of both people and resources. Where will these 11 or so billion people be located and how well aligned will the people be with essential resources? Another issue that complicates any analysis of regional or world carrying capacity is the ability to share or transfer resources effectively. All great modern cities now operate through a worldwide supply network. Countries such as Japan and the United Kingdom thrive at a very high standard of living, while providing only a small portion of consumed natural resources from within their geographic boundaries. Further, there is no assurance that this transfer process can be sustained over time.

Whether it is 8 billion, 11-12 billion, or 50 billion people, no one truly knows how many people the Earth can sustain. Many scientists studying the issue are quite concerned

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[5] Lester Brown and Hal Kane, *Full House: Reassessing the Earth's Carrying Capacity* (New York: Norton, 1994).

[6] Energy is used in the broadest sense in this context. It includes food, heating fuel, and power used to support human activities such as transportation and many other energy consuming activities.

about the currently predicted human population increases and are acutely fearful about several rapidly growing regions with limited resources. If they are correct in their worries about regions with rapid growth, two scenarios seem plausible. First, renewable resources are mined (withdrawn at a faster rate than they are replenished by natural systems) until population far exceeds carrying capacity. This initial population surge then leads to a population die-off. The pressure of a burgeoning population often damages the natural resources to such an extent that there can be a loss in carrying capacity for the region. The large-scale chaos produced by this type of an event would result in a highly insecure world for all nations.

The second scenario is just a bit less threatening, but still involves serious security concerns. Here, resource limitations affect the rate of population growth so that the predicted population is not reached. Famine, disease, increased infant mortality, and the reduction of life expectancy could come to bear as a region reaches the limits of its ability to support the existing population. This scenario may even now be playing out in Africa, where over the last ten years population predictions for sub-Saharan Africa have been reduced to reflect the impacts of disease and other constraining factors.

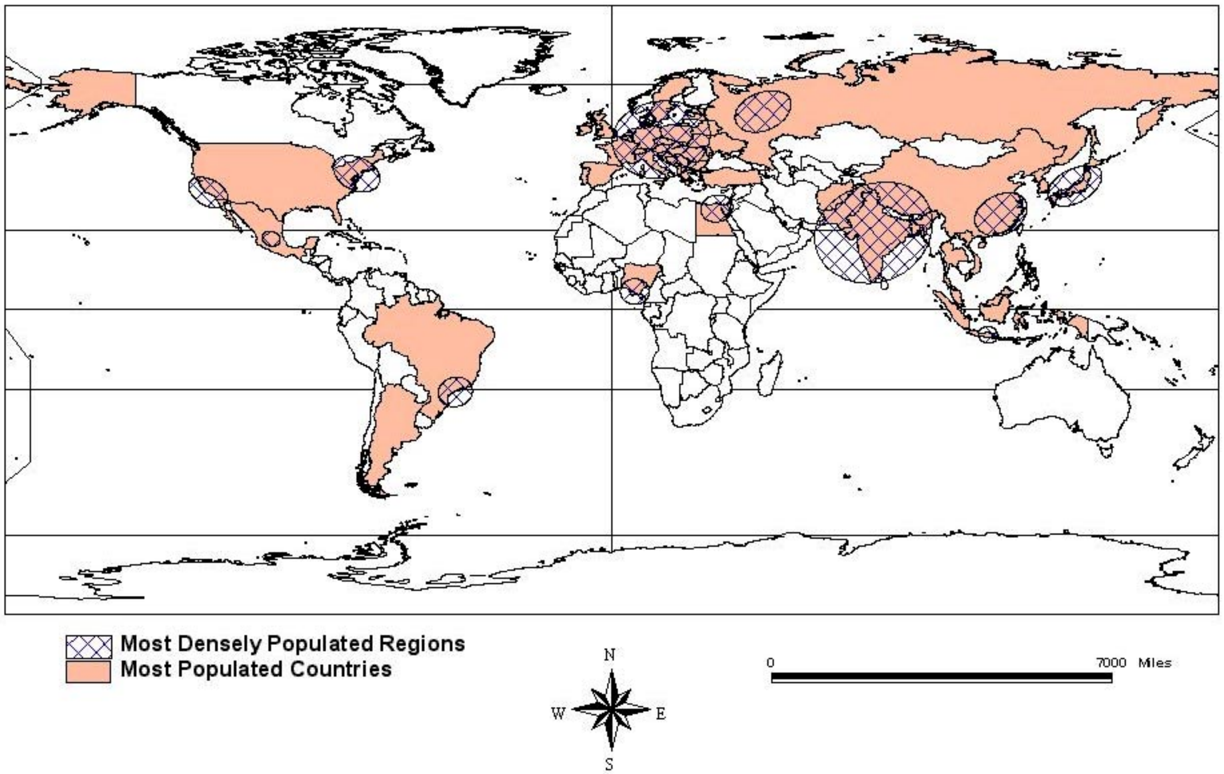
The obvious follow-on question and one that immediately relates to our environmental security analysis is: are there regions of the world that have already exceeded their carrying capacity or are in danger of doing so in the near term?

To begin to address this question it is necessary to examine existing and predicted population growth in a geospatial context. Figure 3-2 is a representation of the most heavily populated regions of the world; Figure 3-3 shows the countries with the highest natural growth rates. Natural growth rate (rate of natural increase) reflects the difference between yearly births and deaths reported as an annual percent change. This statistic does not include changes in a country's population resulting from migrations and therefore may differ from total rate of population growth. Because neither Figure 3-2 nor Figure 3-3 can be interpreted as defining regional carrying capacity, they do not directly answer the question posed. Much more detailed analysis of specific regions will be required, but the data provided in these two figures allow for certain summary inferences. For example, by overlaying areas of high population density with areas of high growth rates we can see the regions that are likely to experience problems in the future.

It is obvious that the west coast of Africa from Cote D'Ivoire to Nigeria, areas of Bangladesh and east India, and the Philippines are areas of high concern. A complete analysis of this type will be conducted in Chapter 4, where, having used environmental issues data to locate areas with resource limitations, we will be able to overlay our population data to identify areas with large and growing populations that also have resource limitations. Such an approach enables us to begin to identify areas where the carrying capacity concept may come into play.

FIGURE 3 – 2

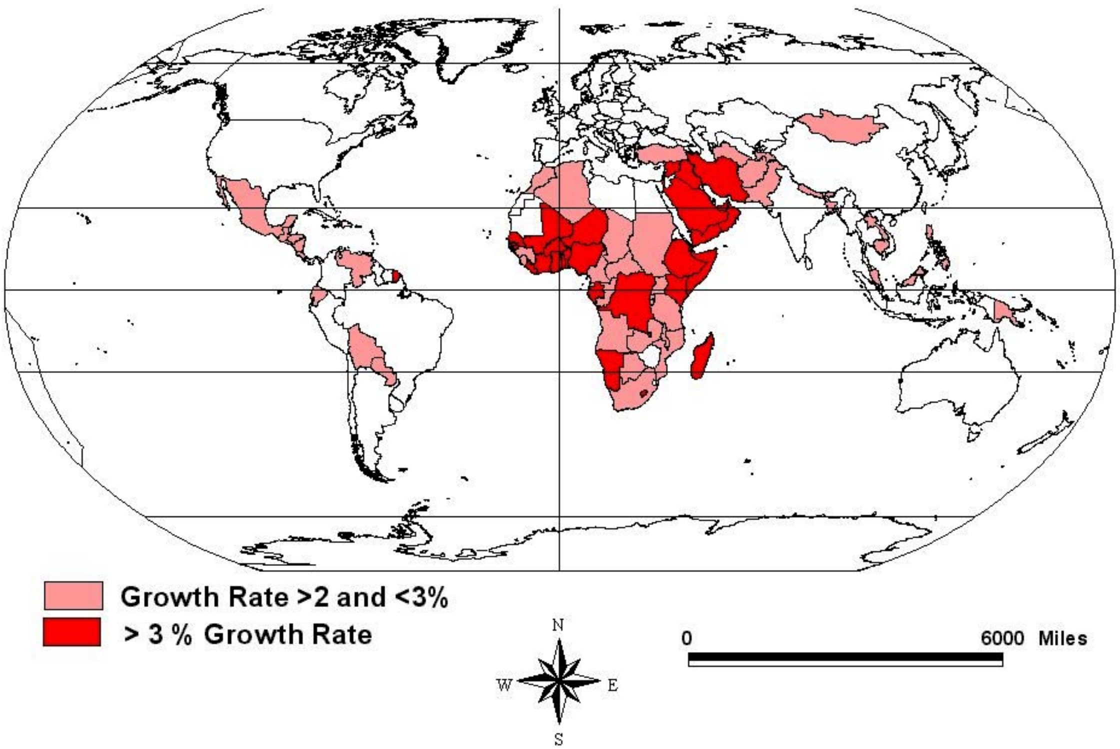
World's Most Populated Countries with High Density Regions



SOURCE: *Goode's World Atlas,* ed. Edward B. Espenshade and others (New York: Rand McNally, 1995), 25.

FIGURE 3 – 3

Population Natural Growth Rates



SOURCE: *Goode's World Atlas,* ed. Edward B. Espenshade and others (New York: Rand McNally, 1995), 27.

This technique of spatial representation and matching of data is the basis of the geographic information system process that has evolved within geospatial sciences and which will be a primary tool for the analysis section of this paper. To the extent that the data are available, environmental issues will be quantified in the same spatial scale, as seen in Figures 3-2 and 3-3, thus allowing for a comparative analysis of regions. The power of this process will be discussed as the data are presented, but a caution must also be issued. All data found in this report are at the macro scale and cannot be used in too precise a manner. This report is meant to help identify areas where theater commanders should focus their detailed analyses. Further, it proposes a methodology that is applicable at any scale where data are available.

A major factor that complicates rigorous application of the principle of carrying capacity to human populations is the perturbing impact of global trends in urbanization. Figure 3-4 shows the results of a trend through which the world population has been transformed from 80 percent rural in 1925 to 52 percent rural today.[7] In some ways, urbanization increases the efficiency of a society in energy and resource use. At the same time, however, it creates high demand areas in regions that may not be capable of sustaining the population. Consider the air pollution problems of major cities such as Los Angeles, Mexico City, or Santiago, Chile, or the water concerns in such places as Tucson, Phoenix, and numerous other towns in the southwestern U.S. These are regions that have exceeded the carrying capacity of at least a part of their natural environment. Depending on the stage of economic development of the society, these types of issues have a greater or lesser impact on the population, but all represent the possibility of environmentally induced strain. The specifics of these problems will be addressed in Chapter 4.

3.1.2 Population Impacts

Most of the analysis of population increase impacts will be done in the following sections on environmental factors, but this section concludes with the hypothesis that there are regions of the world that cannot, even under normal environmental conditions for these regions, support the population that now exists. Such regions lack one or more critical resources—whether water, clean air, or energy (in the broadest sense, including food and power for transportation and other energy-consuming activities)—to provide for the basic requirements of the current population. This seems to be the case for parts of Africa today.

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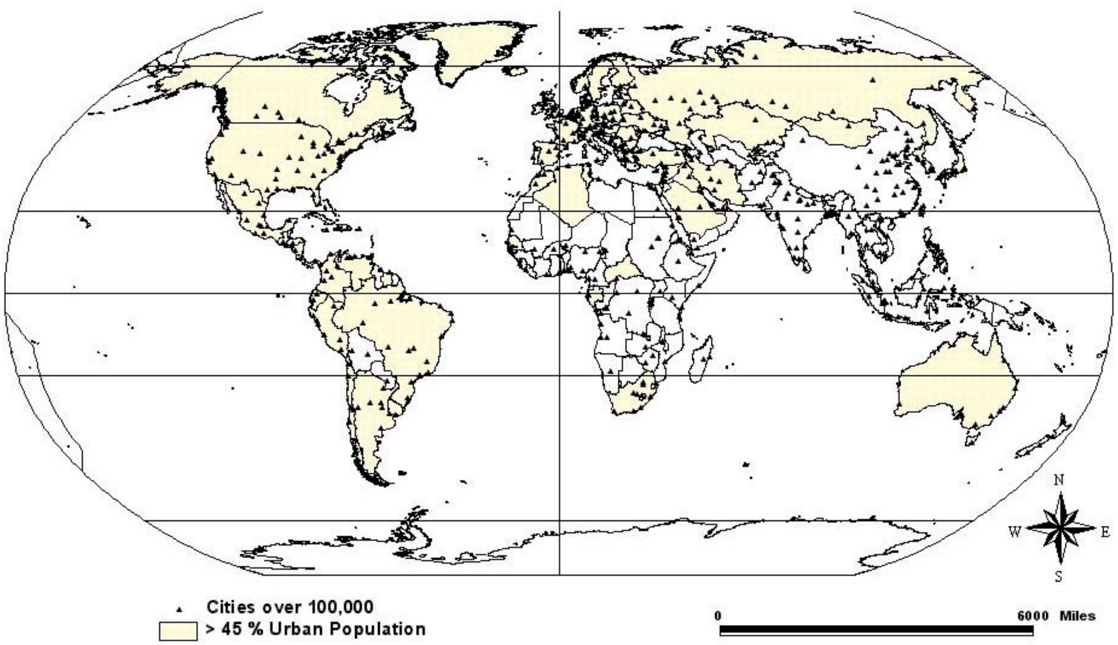
[7] *Goode's World Atlas,* ed. Edward Espenshade and others (New York: Rand McNally, 1995), 27.

FIGURE 3 – 4

Urbanized Countries and Large Cities



SOURCE: *Goode's World Atlas,* ed. Edward B. Espenshade and others (New York: Rand McNally, 1995). Cities from ESRI Data Base, 1999.

In this situation, people first mine the natural resources, consuming water, wood, and other renewable resources at a rate faster than they can be regenerated. Next, people may migrate to a region where they can be better supported, but such opportunities are found less and less in a world of 6 billion. In natural systems, the final stage of this process is the die-off phase described earlier. The human response is much more difficult to predict because more variables come into play. Humanitarian relief to stressed regions is one example of a variable, while human conflict or war is another. In any event, the population must align with the sustainable level of resources and this can mean reduction of the population. Often die-off is precipitated by some environmental event such as a drought or flood. The net impact is that the population suffers a significant reduction over a short period of time. Obviously, each level of this hopeless cycle will increase the insecurity in a region until complete chaos exists.

The term "hopeless" is employed in the sense that the basic principle of carrying capacity cannot be violated over the long term; thus, it is hopeless to expect a region to long support more than its capacity for people. Worse, the first phase, the mining of renewable resources can actually reduce the existing carrying capacity of a land for some period—which can be a very long period for a fragile environment such as a desert or a cold region. To illustrate this concept, we can use the example of agricultural crop rotation, which involves cultivating the land for a period and then allowing a fallow time for the soil to recover. It has been proven that without this recovery period the land produces less and less until it becomes unusable. As will be discussed in the section on desertification, people's actions can critically damage the entire ecosystem of an area.

Many authors continue to suggest that it is the resource side of the problem that must be addressed. Paul Simon's excellent book on water, *Tapped Out—The Coming World Crisis in Water and What We Can Do About It,*[8] takes this general approach, i.e., fix the water problems and we can avoid the crisis. While his concern with water and his solutions are all valid, the underlying principle of carrying capacity cannot be violated. In the water context, the climate provides a watershed with only a fixed amount of water. There is a minimum amount of water required per person each day for survival. The equation then becomes straightforward:

$$\text{Human carrying capacity} = \frac{\text{Gallons of water available per year}}{\text{Gallons per person per year}} \qquad (3\text{-}1)$$

[8] Paul Simon, *Tapped Out* (Champaign, Ill.: Welcome Rain Pub., 1998).

Conservation and other management tools can to some degree change the values in both the numerator and denominator, but cannot change the reality that a given environmental setting can support only a certain number of people.

3.2 Global Climate Change

This environmental security analysis begins with the issue of global climate change because of the high risk of the consequences associated with it. The issue itself is complex and fraught with uncertainties. Some authors writing on global climate change immediately describe the issue as global warming, although their discussions admit a great deal of existing uncertainty. There is a lack of agreement regarding the degree to which human activities are affecting global climate. Further, as is demonstrated in the following discussion, there is little certainty in predicting future climate change. Nevertheless, based on documented anthropogenically produced changes to the atmosphere and employing the risk model of Equation 1-1 (p. 9), there is a sufficiently high probability of occurrence and the potential severity of the consequence is high enough to pose significant risk. Thus, the issue must be seriously considered.

Understanding global climate change is technically complex because of the many dependent variables in the defining equation and because of the natural variability of weather even without anthropogenically induced change. Breaking the impasse on the science of global climate change has required considerable international cooperation, and in a sense can be considered as progress in security because of the many fruitful and cooperative discussions that have ensued. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was formed. Over time the IPCC has produced several significant studies on this subject and has contributed to building consensus and reducing uncertainty. The IPCC results will be the basis for discussion at several points in this review and analysis, particularly in areas where a wide diversity of opinion exists.

3.2.1 Global Warming

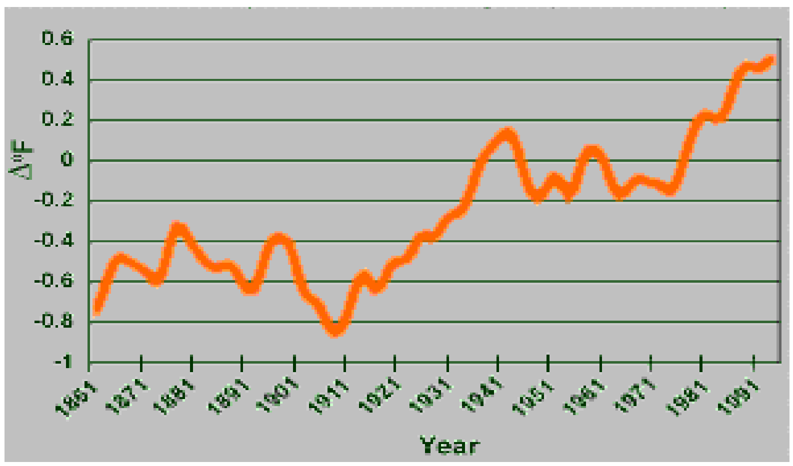
Many scientists, as will be shown shortly, now believe that global climate change in the form of global warming caused by anthropogenic activity is occurring. Driving global climate change is a series of interwoven phenomena including, but not limited to, deforestation,

burning of fossil fuels, and industrial pollution. Assessing each of these factors independently in a static model is within our scientific capability today, but does not yield realistic results. Each activity occurs independently at different rates and concurrently with the natural variability in weather.

Figure 3-5 shows changes in world temperature over the past 135 years, the period for which accurate measured data are available.

FIGURE 3 – 5

Global Temperature Changes (1861–1996)



Source: IPCC (1995), updated.

Many look at these data and conclude that global warming is an acute issue brought on by human abuse of the environment.[9] Others, however, point out that this change over such a minute period in the history of the Earth is well within the statistical bounds of natural fluctuations.[10] Logically, the change illustrated in Figure 3-5 must be the result of both, i.e., the forced changes caused by human inputs imbedded in the natural variability for that period. Unfortunately, there is insufficient scientific understanding to precisely separate the two components at this time.

In attempting to understand global climate change, this study begins by presenting the known factors in the equation, which are primarily the greenhouse effect, the increase in greenhouse gases produced by human activities, and the carbon cycle. With these as a

[9] Rodney White, *North, South, and the Environmental Crisis* (Toronto: University of Toronto Press, 1993), 39.
[10] John Horel and Jack Geisler, *Global Environmental Change* (New York: John Wiley, 1997), 9.

basis one can build on the known science to more competently examine the feasible range of measured changes in the environment and then apply this perspective to determine possible human impacts.

The Greenhouse Effect

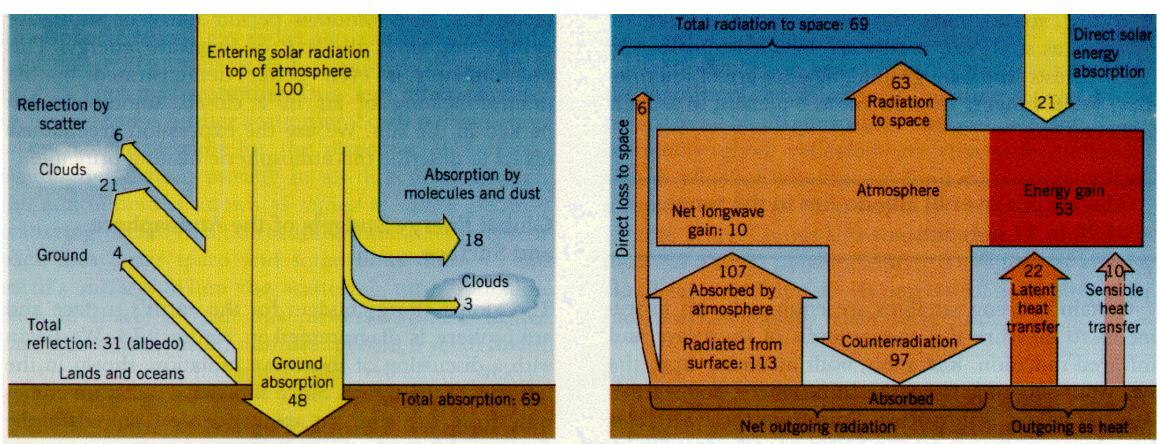
The "greenhouse effect" is a term used to describe the natural process by which the Earth's atmosphere converts the sun's light energy into heat to warm the surface of the Earth and make our planet habitable for all living organisms. The process inherited this name because what occurs in the Earth's atmosphere is not unlike what occurs in a greenhouse, where the sun's energy is naturally collected and retained to help plants grow.

Before beginning our discussion, we must first address and discard a common error: the greenhouse effect is not the "bad" process that causes global warming, though many authors suggest that it is by misusing the term. The greenhouse effect is an essential function of the biosphere without which humans could not inhabitat the Earth.

Figure 3-6 is a simple model of the heating of the Earth's surface by the sun. The sun's energy arrives at the top of the atmosphere as visible or short wavelength radiation, with most energy in the range of 0.3 to 0.7 micrometers. Each component (whether gas or particle) of the atmosphere has as one of its basic material properties a specific way of interacting with the

FIGURE 3 – 6

Global Energy Balance



SOURCE: Alan Strahler and Arthur Strahler, *Introducing Physical Geography* (New York: John Wiley, 2000), 43.

electromagnetic energy that strikes it; each element of energy will be reflected, absorbed, or transmitted (pass through the component). For example, oxygen, which makes up just over 20 percent by weight of our atmosphere, absorbs most light below 0.3 micrometers wavelength and is transparent to all longer wavelength energy. Nitrogen (80 percent of air) is transparent to all visible (short wavelength) and heat radiation (long wavelength or infrared). As indicated in Figure 3-6, clouds, the ground, and the air reflect a small percentage of light; the atmosphere absorbs a small amount; but the ground absorbs about half of the sun's light energy. The light directly reflected by the ground does not change wavelengths; therefore, it will travel back into space because it remains transparent to the atmospheric gases. The unreflected energy reaching the Earth's surface is either absorbed at the surface or is captured for use by photosynthetic plants. The absorption of energy by soil, rocks, and other materials warms Earth's surface. Since all warm bodies emit heat energy (see the right side of Figure 3-6) as longer wavelength radiation (4–20 micrometers), the Earth's surface becomes a source for infrared radiation. This long wavelength energy is transmitted through oxygen and nitrogen, but is absorbed at different rates by several of the minor constituents of the atmosphere, both those that are naturally occurring and anthropogenically generated substances.

Greenhouse Gases

Gases that have the ability to absorb thermal wavelength energy have been defined as "greenhouse gases." Table 3-1 lists the greenhouse gases, their current atmospheric concentrations, their relative absorptive capacities, and other important properties that will further our understanding of the greenhouse effect.

The greenhouse effect is, then, the warming of the atmosphere close to the ground by certain gases absorbing heat radiated from surface materials. Since the amount of energy input by the sun is relatively constant from year to year, the temperature of the Earth's atmosphere is regulated by the concentration of the greenhouse gases listed in Table 3-1. Each gas enters and leaves the atmosphere at a rate determined by both natural cycles and inputs from human activity. Increases in the quantity of these gases present in the atmosphere disturb the balance and could influence atmospheric temperatures. Many knowledgeable scientists have concluded that the increase of greenhouse gases, particularly carbon dioxide, is causing an "enhanced greenhouse effect" and that this is the cause of the global warming reflected in Figure 3-5.[11]

[11] John Houghton, *Global Warming* (Oxford, England: Lion Publ., 1994).

TABLE 3 – 1

Properties of Greenhouse Gases

Chemical	Preindustrial Atmospheric Concentration	Concentration in 1994	Absorption wavelengths in the thermal range (micrometers)	Residence Time in the Atmosphere (years)	Strength of Absorption Relative to Carbon Dioxide
Carbon Dioxide, CO_2	280 ppm	360 ppm	>10	3	1
Methane, CH_4	0.8 ppm	1.7 ppm	3 & 7	10	20
Freon, CFC-11&12	0	0.76 ppb	8 – 12	100	12,000
Nitrous Oxide, N_2O	0.288 ppb	0.31 ppb	8	150	200
Water, H_2O	Varies	Varies	3, 6, & 11	-	-

Notes: ppm = parts per million in volume to volume ratio; ppb = parts per billion by volume

SOURCES: Compiled from Noel de Nevers, *Air Pollution Control Engineering* (Boston: McGraw-Hill, 2000), 523; John Horel and Jack Geisler, *Global Environmental Change* (New York: John Wiley, 1997), 98; and John Houghton, *Global Warming* (Oxford, England: Lion Publ., 1994), 22.

At this point, an examination of the greenhouse gases on an individual basis will allow for a better interpretation of their impacts on the environment. We will begin with the gases that have the least impact and work up to our major concern, carbon dioxide (CO_2).

Nitrous oxide (also known as laughing gas) is a relatively minor component of the environment and one that has grown only slightly with industrialization. There are both natural and human sources for nitrous oxide; these include natural biological processes, chemical manufacturing, and motor vehicle emissions. The rate of production from all of these sources is not large enough to suggest big changes in atmospheric nitrous oxide concentration in the future. Nitrous oxide is a gas that persists in the environment and is a strong energy absorber; therefore, any new major sources would be of concern. But again, without significant changes in atmospheric concentration, nitrous oxide is not expected to further impact the global climate.

Freon is a common name for the most important forms of a class of chemicals more precisely described as chlorinated fluorocarbons (CFCs). CFCs are a class of synthetic chemicals used in the past as carrier gases for aerosol spray cans and, more important, as gases used to produce the cooling reaction in refrigeration compressors. Much more attention will be given to CFCs when the problem of the hole in the ozone layer is discussed, but CFCs are also greenhouse gases because they very efficiently absorb thermal energy. Table 3-1 shows that CFCs are also highly persistent. Thus, at even small concentrations, they can contribute to the enhanced greenhouse effect. Noel de Nevers estimates that 24 percent of the anthropogenic

enhanced greenhouse effect is the result of CFCs.[12] If the concentration of CFCs were to continue to increase, they would be of major environmental concern. Later in this chapter we will discuss the good news story of a worldwide effort to phase out the use of CFCs. The bad news, however, is that even though the concentration of CFCs in the atmosphere is being reduced, an atmospheric residence time of 100 years is going to make recovery very slow.

Methane is a naturally occurring gas that is also a by-product of many industrial processes and is the major component of the fuel called "natural gas." Biochemical reactions that proceed in the absence of oxygen produce methane (swamp gas) as a by-product. Wetlands and paddy agriculture are the major sources of methane, followed by sources from the livestock production industry. Because methane is 20 times stronger than CO_2 in its greenhouse impact, is increasing, and has sources that are crosslinked to population, methane is a concern in the enhanced greenhouse effect.

With regard to anthropogenic sources of the enhanced greenhouse effect, CO_2 concentration in the atmosphere is the big issue. There is complete certainty that, over the short term of atmospheric measurement available, the concentration of CO_2 in the air is increasing and burning of fossil fuels is the cause. Figure 3-7 shows the trend in carbon dioxide concentration over the past 300 years with an expanded view since 1960. One cannot but notice the striking similarity in shape between this figure and Figure 3-5 (global temperature changes). Is this merely a coincidence? A mass balance of the total carbon in the environment as depicted in Figure 3-8 shows that fossil fuel burning and deforestation (which will be discussed later in this chapter) are adding CO_2 to the air faster than natural systems can remove it, with a net increase of 3.5 gigatonnes per year.

A common misconception about global warming arising from poor science reported in the news media is that CO_2 is produced because of improper burning of fossil fuels. Carbon dioxide is the clean by-product of the complete combustion of all fossil fuels and is not created by improper burning. This can be represented chemically as,

$$\text{Coal/petroleum/natural gas/wood} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water} \qquad (3\text{-}2)$$

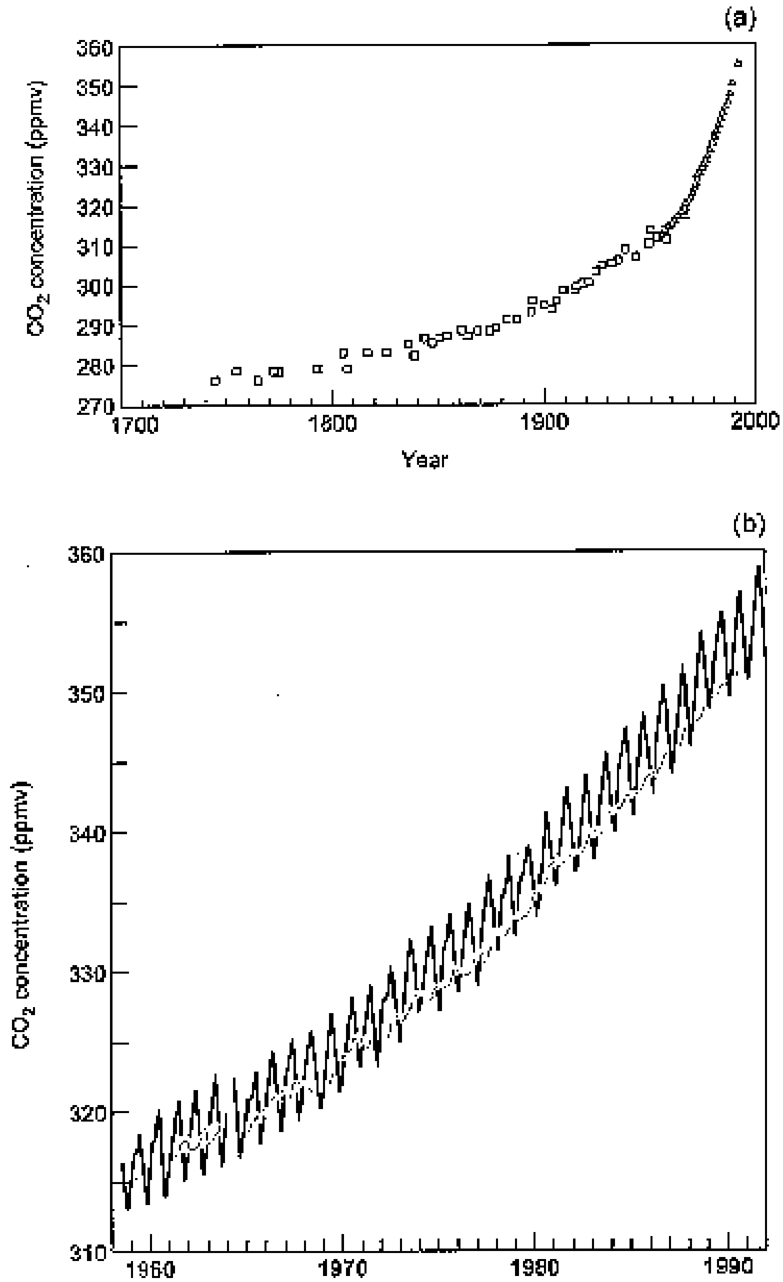
Poor combustion processes produce carbon monoxide (CO), which is an air pollutant because of its deleterious health impacts, asphyxiation being the most acute. The only way of reducing CO_2 production in burning coal, gasoline, or natural gas is to burn less fuel.

[12] Noel de Nevers, *Air Pollution Control Engineering* (Boston: McGraw-Hill, 2000), 517.

FIGURE 3 – 7
Carbon Dioxide Concentrations

a) 1700 – 1990s

b) 1960 to 1994 as measured at Mauna Loa Hawaii



SOURCE: John Houghton, *Global Warming* (Oxford, England: Lion Publ., 1994), 31.

The Carbon Cycle

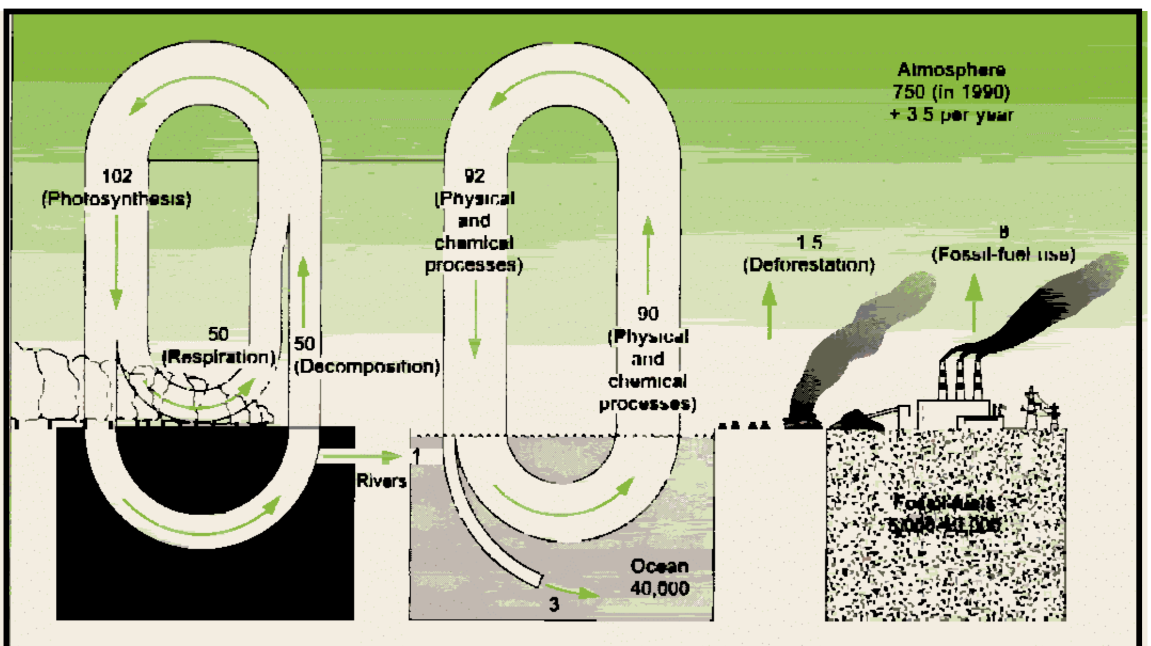
The fate of the carbon dioxide in the air is described as a part of the carbon cycle, a complex, dynamic system of chemical and biological processes illustrated in Figure 3-8. First, we need to recognize that there is a natural or good concentration of CO_2 in air that is essential for photosynthetic reactions in green plants. On land, photosynthesis captures CO_2, storing carbon in plant biomass and releasing oxygen back to the environment. The carbon can be released back to the atmosphere by natural decomposition or human activities (such as burning of fuels). The reactions in the ocean are more complex because both chemical and biological processes come into play in transporting CO_2 from the air to the water and through living organisms, with waste products either returning to the air or sinking to the bottom of the ocean where they are retained for long periods.

One of the uncertainties in global warming has to do with the role played by chemical reaction kinetics. It is known that for all chemical and biological reactions, an increase in one

FIGURE 3 – 8

The Carbon Cycle

(1990 data)



Land Biota, Soil, Peat
2000

Units for all masses are gigatonnes

SOURCE: John Houghton, *Global Warming* (Oxford, England: Lion Publ., 1994), 30.

of the inputs (reactants) increases the rate at which reactions occur and the quantity of products produced. This leads to the hypothesis that an increase of CO_2 in the air can/will cause an increase in the uptake rate of CO_2 and thereby compensate for or moderate the rate of increase of CO_2 in the atmosphere. Whether or not this theory proves true, Figure 3-7 indicates that this type of regulation has not occurred or, if it has occurred, its effects have not been strong enough to counterbalance the large CO_2 inputs occurring today.

John Houghton and others provide excellent discussions of the many different scenarios that can be used to predict carbon dioxide concentrations in the year 2100.[13] Even with the uncertainties in the science, all models indicate that the rate of fossil fuel burning regulates CO_2 levels. The optimistic predictions are for CO_2 to level off at just over 400 parts per million (ppm) and pessimistic estimates predict CO_2 exceeding 700 ppm by 2100. This is the first major uncertainty in understanding global warming: how will carbon dioxide produced by man-made and natural processes impact the global climate, and what will the concentration of CO_2 in the air be in the future?

Table 3-2 presents the release rates for greenhouse gases (GHG) as self-reported by the major producers in the world.[14] The United States produces 25 percent of the world's carbon releases and our burning of carbon fuels continues to increase over time. Without a paradigm shift in use patterns in the predictable future, there will continue to be a growth in greenhouse gases, dominated by CO_2 production.

3.2.2 Impacts of Global Climate Change

The preceding discussion alluded to the fact that the uncertainty challenging scientists' understanding of the enhanced greenhouse effect has to do with defining the relationship between changes in GHG concentrations in the air and changes in global climate. The consensus of scientists today is that increases in CO_2 will have a direct impact on temperature. Specifically, increases in CO_2 will produce increases in global temperatures. We have already noted that a comparison of Figure 3-5 (global temperature change) with Figure 3-7 (CO_2 concentrations) suggests a very strong correlation between the two, but it would be simplistic to draw rigorous scientific conclusions from this observation. Predicting temperature change within the dynamics of greenhouse gas behavior and natural climate processes

[13] Houghton, 37.
[14] USEPA, website: www.epa.gov/globalwarming/emissions/international/inventories.html, April 2000.

TABLE 3 – 2

Aggregate Greenhouse Gas Emissions, Excluding Land-Use Change and Forestry

(MMTCE)

Country	1990	1991	1992	1993	1994	1995	1996
Australia	113.4	113.4	114.5	114.5	115.6	118.8	121.6
Austria	21.1	22.3	20.7	20.4	20.4	21.5	21.9
Belgium	37.9	39.0	38.3	37.9	39.4	39.6	41.4
Canada	163.1	161.5	164.7	168.0	172.9	178.2	183.1
Czech Republic	52.4	48.2	44.5	43.0	40.9	41.2	41.9
Denmark	19.5	22.5	21.1	21.5	22.5	21.5	25.3
France	151.9	158.0	155.0	147.4	147.4	149.4	153.3
Germany	329.8	316.6	303.4	300.1	296.8	292.8	297.6
Greece	28.7	28.7	29.0	29.3	29.8	30.6	31.3
Ireland	15.5	15.4	15.5	15.5	16.0	16.2	16.3
Japan	333.2	339.9	346.5	343.2	363.2	368.8	-
Latvia	9.7	8.0	7.0	6.0	5.3	5.2	4.9
Monaco	0.03	0.04	0.04	0.04	0.04	0.04	0.04
Netherlands	59.2	61.0	60.4	61.0	61.6	63.9	66.3
New Zealand	19.8	19.8	19.9	19.9	19.8	19.8	20.4
Norway	15.0	14.4	14.0	14.6	15.2	15.3	16.1
Slovakia	19.8	17.4	16.0	15.2	14.2	14.8	15.0
Sweden	17.8	17.6	17.9	17.9	18.5	18.3	19.8
Switzerland	14.7	15.1	14.8	14.4	14.2	14.4	14.6
United Kingdom	206.7	206.7	200.5	194.3	192.2	189.6	195.5
United States*	1,632.1	1,620.0	1,645.2	1,675.0	1,713.2	1,733.9	1,790.5

- Data not available
* Emissions data taken from the latest “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1997.”

Source: USEPA website: www.epa.gov/globalwarming/emissions/international/inventories.html, April 2000.

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is a key area of uncertainty in the global warming debate. Several complex computer models have been developed and are being continually updated, but each has its strengths and weaknesses. Here we come to yet another major area of uncertainty, knowing how much the temperature will change as greenhouse gases increase.

A wide range of temperature predictions exists, but they generally fall in the 0.5 – 5.0^{o} C range. To proceed further with this analysis of estimates of impacts from the enhanced greenhouse effect, we will need to choose a temperature prediction from this range. This study will use the figures projected by the IPCC and supported by the USEPA, or a 1 to 3.5 ^{o}

C temperature increase by 2100.[15] The reason for our choice is that these figures represent the consensus values of scientists worldwide and have received the most scrutiny.

This introduces another area of uncertainty into the global warming debate, and arguably the one of greatest contention in the scientific community. Again, complex interactions between systems, actions, and counteractions of the carbon cycle and other processes make it difficult to determine exactly how atmospheric warming will change the Earth's atmosphere. Based on our current understanding of climate and weather, a rise in temperatures worldwide and changes in temperature distribution, spatially and temporally, will change weather and climate over large areas of the Earth. Weather is primarily driven by the sun's energy being unequally distributed over space and time. Higher temperatures will produce more evaporation from the oceans and this will increase rains somewhere. Higher temperatures over land will increase evaporation of soil moisture, raise dry soil temperatures, and melt ice. All of these factors will combine to change the weather patterns of a particular region, in both frequency and intensity of events. These can over time sum to changes in climate regions in many parts of the world. Grasslands, forests, and deserts may shift due to evolving climates.

Sea level rise as a direct response to global warming has been the issue that seems to have captured the most public attention, although there are many other equally important possibilities that must be assessed, particularly in considering environmental security. Based on scientific analysis to date, the range of sea level rise is predicted to be between -1 and +6 meters, not a particularly informative range to use in assessing impacts. However, the factors that enter into this calculation are fairly well defined.

First, warm water occupies a larger volume than cold water, so as ocean surface temperatures warm because of contact with the warmer air, the volume of the ocean will increase, resulting in a rise in sea level. The more difficult factor to calculate is the depth change attributable to warmer air temperatures occurring in regions with snow and ice cover. Uncertainty about whether and how much ice will melt under different warming predictions accounts for the wide range in the sea level rise estimates. Using the IPCC warming estimate as a basis for temperature rise,[16] Houghton predicts a 50-centimeter (1.65 feet) sea level rise by the year 2100. The most detailed statistical analysis of sea rise predicts a 35 cm rise by 2100 as the most likely result, with a 10 percent chance of sea rise reaching 65 centimeters, and a 1 percent chance of a 1 meter rise.[17] This rise, coupled with natural land subsidence in some lowland regions, could have large impacts in several critical areas of the world, such as

[15] USEPA, website: www.epa.gov/globalwarming/publications/reference/ipcc/summary/page4.html, April 2000.
[16] IPCC, *Climate Change 1992* (Geneva: United Nations, 1992).
[17] James Titus and Vijay Narayanan, *The Probability of Sea Level Rise* (Washington, D.C.: USEPA, 1995).

Bangladesh and Egypt.[18] The significance of this with regard to security will be discussed in the next chapter.

There is some scientific certainty that changes in weather will impact water resources, food production, human health, weather events such as floods and other "natural disasters," and coastal processes, all of which have peace and security implications. In this researcher's view, these are more difficult impacts to predict than sea level rise. In order to realistically predict the impacts of global climate change it will be necessary to input the variables with the accumulated uncertainties mentioned above into the same weather and climate models that are now employed to predict the weather.

Figure 3-9 is one estimate of climate change based on continued discharge of greenhouse gases at the IPCC predicted "business as usual" rate. This figure characterizes changes in climate that could occur in five regions of the world. Looking at the area of the United States depicted in this figure as a familiar example, we can see the impacts such a climate change might produce. The central U.S. is a rich agricultural area that relies extensively on irrigation, primarily using groundwater to increase production. The predicted drier summer months would cause either lower production rates or increase the need for irrigation, assuming the water was available. The groundwater source for this region is the Ogallala aquifer. This massive aquifer is the primary water source for a large part of the middle U.S., from Minnesota all the way to the Texas/Mexico border. Water levels are already dropping rapidly in this aquifer, largely as a result of agricultural uses in the upper Midwest that actively mine the aquifer. Current use rates threaten water supplies over this entire region.[19]

The difficulties in predicting impacts of climate change can be appreciated by considering the two questions below:

a. Will the predicted increases in rain in the winter recharge the aquifer sufficiently so that additional water can be used in irrigation in the summer over an indefinite period and possibly increase production through a longer growing season?

Or

b. Will the needed additional summer withdrawals further deplete the aquifer and endanger water supplies throughout the aquifer, ultimately drying up much of southern Texas?

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[18] Houghton, 91.
[19] Simon, 43-45.

FIGURE 3 – 9

Houghton's Predictions of Climate Change

Estimates of regional changes by 2030[8]

In the IPCC 1990 report, estimates were given for climate changes by the year 2030 under a business-as-usual scenario of greenhouse gas emissions, for the five regions shown in the map of Fig. 6.4. These regional estimates can be summarized as follows:

Central North America
Warming varies from 2 to 4°C in winter and 2 to 3°C in summer. Precipitation increases up to 15 per cent in winter whereas there are decreases of 5 to 10 per cent in summer. Soil moisture decreases in summer by 15 to 20 per cent.

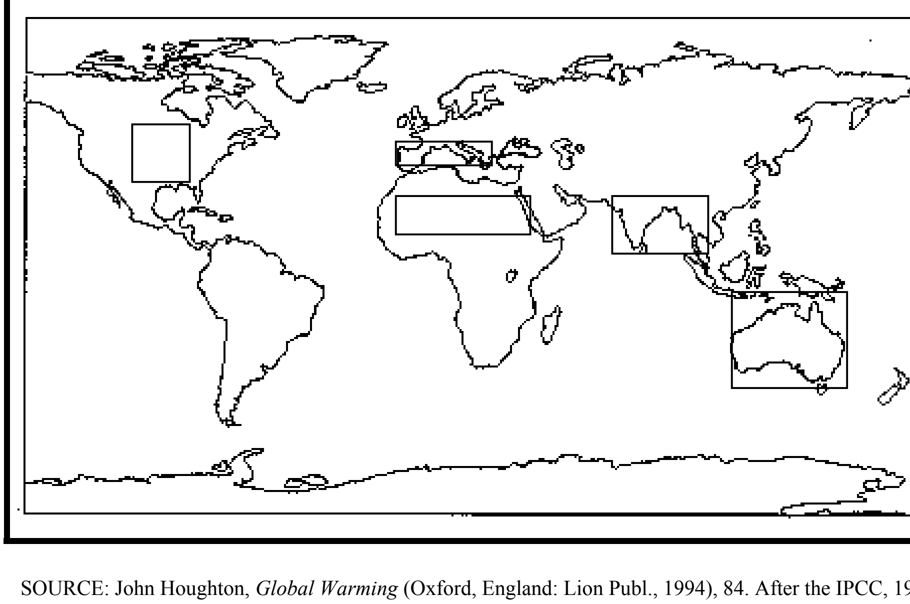
Southern Asia
Warming varies from 1 to 2°C throughout the year. Precipitation changes little in winter, but in the summer monsoon increases by 5 to 15 per cent[9]. Summer soil moisture increases by 5 to 10 per cent.

Sahel region of Africa
Warming ranges from 1 to 3°C. Area mean rainfall increases and area mean soil moisture decreases marginally in summer. However, within the region, there are areas of both increase and decrease in rainfall and soil moisture.

Southern Europe
Warming is about 2°C in winter and varies from 2 to 3°C in summer. There is some indication of increased precipitation in winter, but summer precipitation decreases by 5 to 15 per cent, and summer soil moisture by 15 to 25 per cent.

Australia
The warming ranges from 1 to 2°C in summer and is about 2°C in winter. Summer precipitation increases by about 10 per cent, but the models do not produce any consistent estimates of the changes in soil moisture. The area averages hide large variations at the sub-continental level.

FIG. 6.4 **Map of regions chosen for estimates of regional climate change.**



SOURCE: John Houghton, *Global Warming* (Oxford, England: Lion Publ., 1994), 84. After the IPCC, 1990.

Current scientific understanding does not provide a definitive answer to these questions today, although this is one of the most studied geohydrologic systems in the world. Clearly, even in the country of the world most capable of mitigating change, the impacts on economics, quality of life, and other secondary elements could be immense.

Table 3-3 presents a synthesis of predicted worldwide impacts from regional climate change based upon IPCC Global Climate Change studies, as summarized by the USEPA. As indicated in the table, regions relying on single-crop agriculture and subsistence farming, such as tropical Asia and Africa, are particularly vulnerable to changes in weather patterns. Vector and water-borne disease is expected to rise in the developing regions of the world and areas where more extremes in weather will increase the frequency of weather-driven disasters. The strategic significance of the data contained in the table will be analyzed in the next chapter.

Many of the environmental issues discussed later in this chapter are inexorably linked to global climate change—water as a scarce resource, desertification, and deforestation being prime examples. While the data are not specific in terms of exactly where impacts will be seen, they do suggest that the basic carrying capacities of many regions will change, which implies that populations will need to shift in response. Overall, the impacts of global warming as predicted by this review will be a major destabilizing influence on the security of the world and will constitute a major causative factor in population migration.

3.2.3 El Niño / La Niña

Occasionally "news and information reporting" associate the climate phenomena El Niño and La Niña with the enhanced greenhouse effect and global climate change, but scientists now better understand that these phenomena are natural. El Niño is a period of unusually warm water temperatures and increased early winter rain along the western coast of South America centered on Peru. Historically, the local residents named this periodic change in weather El Niño because it generally appeared around Christmas, and thus they associated it with the birth of "The Child," El Niño. The term La Niña came from scientists who coined the expression to refer to the periods of normal (cold) water temperatures in the Pacific and thus, normal weather patterns along the coast of South America.

The world became concerned with El Niño as these rains, combined with the impacts of deforestation in some areas, produced floods and mudslides, occasionally causing great destruction in the region and killing or injuring many people. A second concern related to El

TABLE 3 – 3
Regional Impacts of Enhanced Greenhouse Effects on Climate

IMPACTS	North America	Tropical Asia	Temperate Asia	Arid Western Asia	Europe	Africa	Australasia
Geographic Area	Canada, US, and Arctic Circle	India, Pakistan, Bangladesh, Vietnam, Malaysia, and inclusive counties.	Japan, Koreas, Mongolia, most of China, and Russian Siberia	Turkey in the west to Kazakstan in the east.	West of Ural Mountains	The continent	Australia, New Zealand, and islands
Ecosystem	Shifts in location of forests and croplands; change of vegetation types; loss of waterfowl habitat	Changes in distribution of rainforest; drying of wetlands.	Reduction in the boreal forests, expanded grasslands, decrease in the tundra zone.	No large changes.	Mostly disturbed environment now. Alter wetlands through lower ground water levels	Desertification in north, loss of forests in SubSahara; deterioration of land cover. Major impacts expected throughout.	Alterations of soils and vegetation could be large.
Hydrology and Water Resources	Increased Spring and Winter runoff; decreased rain and soil moisture in summer.	Glaciers recede in Himalayas; more seasonal impacts,	Net decrease in water supply; glacier melt; North China water supplies vulnerable.	Continued water shortages in the region.	Increased precipitation in high latitudes and reduced in lower; loss of glaciers with water storage processes.	Reduction in supplies in Sahel and southern Africa. Acute concern in many already water scarce countries of the region.	Reduce water could be critical in drought prone areas; loss of snow and glaciers in New Zealand; flooding.
Food and Fiber Production	Small changes, plus and minus inputs	Vulnerable to natural disasters. Changes in production and yield very difficult to predict, but crops are sensitive to temperature and moisture.	Not agreement in predicted change;	No large net change.	Shift of growing seasons and patterns. Possible increased production.	Water shortages could be acute to farming in the North. Winter wheat growing in north hurt. Could have moderate increases in the south.	Early increased production predicted, but uncertain long-term impacts.
Human settlements	Changes in energy use; increased natural hazards.	Inundation of lowland cities,; salt water intrusion into water supplies in lowlands	Land subsidence in lowlands, slat water intrusion in water supplies	No large impacts	Flooding of more inhabited areas. Cooling demands higher, heating demands lower.	Increased exposure to natural disasters; urban water supplies threatened. Sanitation and waste disposal problems expand.	No large impacts expected
Coastal Systems	Up to 19,000 km^2 inundated; 23,000km^2 added to floodplain	Large and productive lowlands flooded; more natural hazards impacts; millions displaced by 1 m sea rise.	Japanese industry in coastal zones; large areas inundated	No large issues.	Risk of storm surges in lowland coasts of Holland, Germany Russia, and Ukraine.	Coastal erosion in central coastal areas, particularly in storm impacted west Africa. Flooding of Nile delta of concern.	Highly vulnerable to flooding and inundation
Human Health	None predicted	Increase in vector and water borne disease, malaria, dengue, and schistosomiasis	Increased transmission of vector borne disease.	Small increases in disease and heat induced health problems	No major changes	All types of disease exacerbated by malnutrition would further damage the overall health of the people of Africa.	Small increases in disease and heat induced health problems.

SOURCE: USEPA, website: www.epa.gov/globalwarming/publications/reference/ipcc/summary/page4.html

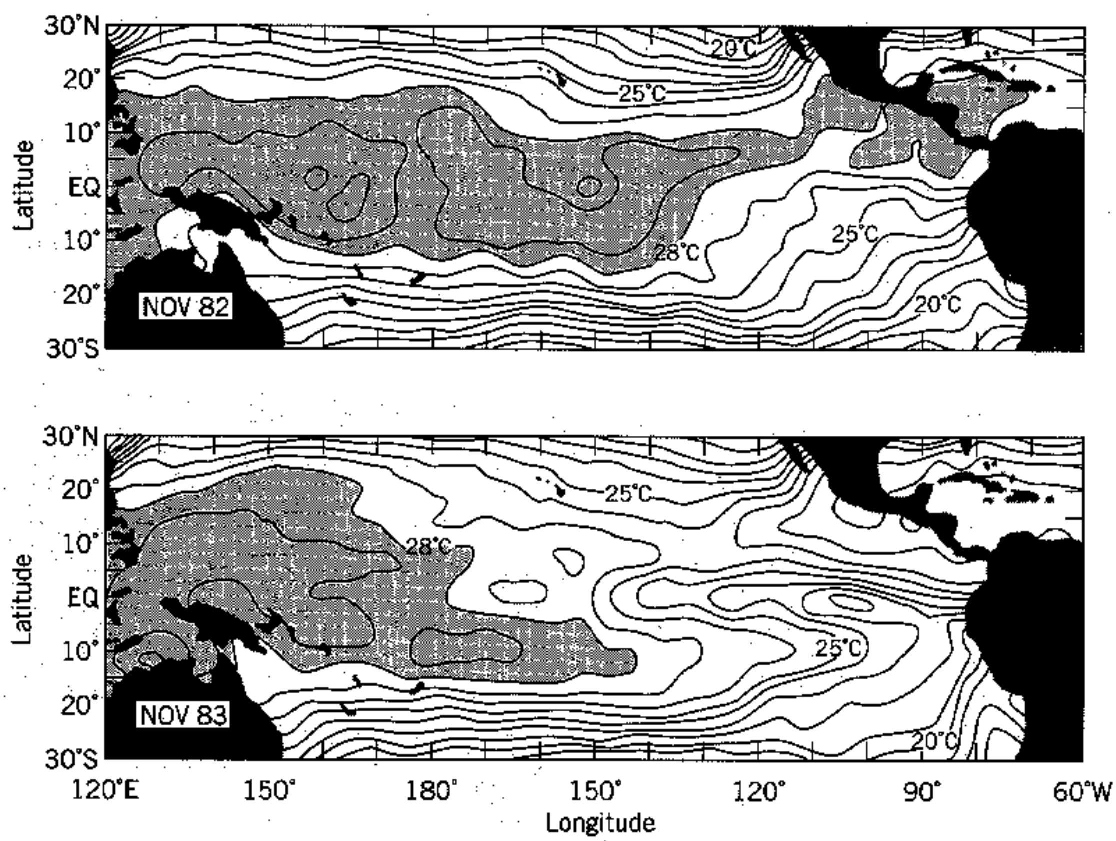
Niño is the impact that the unusually warm water temperature has on the rich fishing waters off the coast of Peru. The warmer waters result in a depletion of the nutrient supply, which causes fish die-off; further, many valuable natural species intolerant of the warmer water may migrate from the region.[20]

The frequency of El Niño events and the exact reasons for their timing remains unknown, but the conditions required to produce an El Niño have been identified. Figure 3-10 shows the surface water temperature profiles of the Pacific for El Niño and La Niña conditions.

FIGURE 3 – 10

Surface Water Temperatures in the Pacific Ocean

Top view shows El Niño conditions
Bottom view shows normal conditions (La Niña)



Note: The gray area shows the extent of the warm waters (28 C°)

SOURCE: John Horel and Jack Geisler, *Global Environmental Change* (New York: John Wiley, 1997), 60.

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[20] Horel and Geisler, 59-63.

It is known that the size of the warm water pool in the Pacific grows at times when the normally cool easterly winds along the equator slow, thereby reducing the cooling impact they have on water temperatures in the Pacific Ocean and bringing the warmer waters closer to South America. As water temperatures rise over a larger area of the Pacific, net evaporation increases greatly. This produces more moisture in the atmosphere—moisture that eventually becomes rain—and intensifies the low-pressure cells created by the rising warm moist air. These large low-pressure areas become the engines inducing air movements throughout the region. The net result is intense rainfall events over areas of the west coast of South America. There are data suggesting that El Niño also produces corresponding drier areas in Central America, but the evidence for this impact is not as conclusive.

The El Niño/La Niña cycle is of special interest to scientists for two reasons. First, there are questions as to whether global warming may change the frequency and magnitude of El Niño occurrences, and thus the weather patterns that result. Second, El Niño is a natural weather experiment that can be studied to advance understanding of the scientific relationships between ocean behavior and terrestrial weather. By watching and measuring the cause and effect relationships of the weather generated during El Niño and La Niña periods, it may be possible to build and test better weather models.

From an environmental security standpoint, the military is concerned primarily with the impacts of El Niño. The military has already been involved in humanitarian relief missions in South America in response to the floods and mudslides associated with El Niño, therefore, the better understood the science, the better the military can prepare and respond. Further, if global warming makes El Niño occurrences more common, as some predict, this could become a significant issue for the U.S. Southern Command.

3.2.4 Ozone Depletion in the Stratosphere

It is important to begin by recognizing that there are two kinds of ozone, which can be referred to as “good ozone” and “bad ozone”—and it is very easy to confuse the two. “Bad ozone,” which is really not the subject of this discussion, is the ozone that exists in the lower atmosphere within the living space of plants and animals. Chemically, ozone (O_3) is a highly reactive oxidizing agent, similar in properties to chlorine bleach, with the ability to damage most organic materials. This “bad ozone” kills vegetation, burns the lungs of mammals at even small concentrations, contributes to the production of photochemical smog, and has

several other negative impacts—so much so that it is a primary air pollutant strictly regulated by the USEPA.

The "good ozone," which is the subject of our concern here, is the ozone that exists in the upper atmosphere. It is primarily produced in the upper stratosphere (25–50 kilometers) and stored in the lower stratosphere in a band 10 to 20 kilometers above the Earth. Recall the earlier discussion of the photochemical properties of the greenhouse gases and how each gas absorbs specific wavelengths of radiant energy at different rates. Ozone is a strong absorber of ultraviolet light (UV), wavelengths below 0.28 micrometers. The sun emits a large quantity of this energy spectrum into the Earth's upper atmosphere. If allowed to reach the ground, the UV radiation would cause significant harm to many of the living organisms on earth—including humans. Large doses of radiation at these wavelengths are known to increase the incidence of cancer in humans, and we have documented evidence of deleterious impacts on other animals and many plants.

Depletion of stratospheric ozone became an issue when a hole in the ozone layer over the South Pole was first detected in 1985 through the use of new space-based remote sensing technologies. Since then, considerable effort has gone into understanding the complex chemistry involved in ozone depletion and determining its causes. Scientists have identified chlorine compounds, particularly chlorinated fluorocarbons (CFCs) as the primary culprits in this mystery. CFCs and specifically freons had become ubiquitous in home and commercial use as refrigerants. Since there was no known harm from them, they were routinely discharged to the environment after use. The chemical reactions that take place in the atmosphere are complex, light-activated processes where ozone is broken down into oxygen (O_2) with chlorine serving as a catalyst in the reaction. Since chlorine is only a catalyst, it is not consumed in the reaction. These reactions occur at higher rates in the South Pole region because in extremely cold temperatures ice crystals form which further catalyze or enhance the reactions.

Because chlorine is not bound into the products of the reaction, a small amount of chlorine continues to propagate these reactions for long periods. Freons, which represent more than 50 percent of the ozone depleting chemicals already in the stratosphere, have an atmospheric lifetime of 80 years.[21]

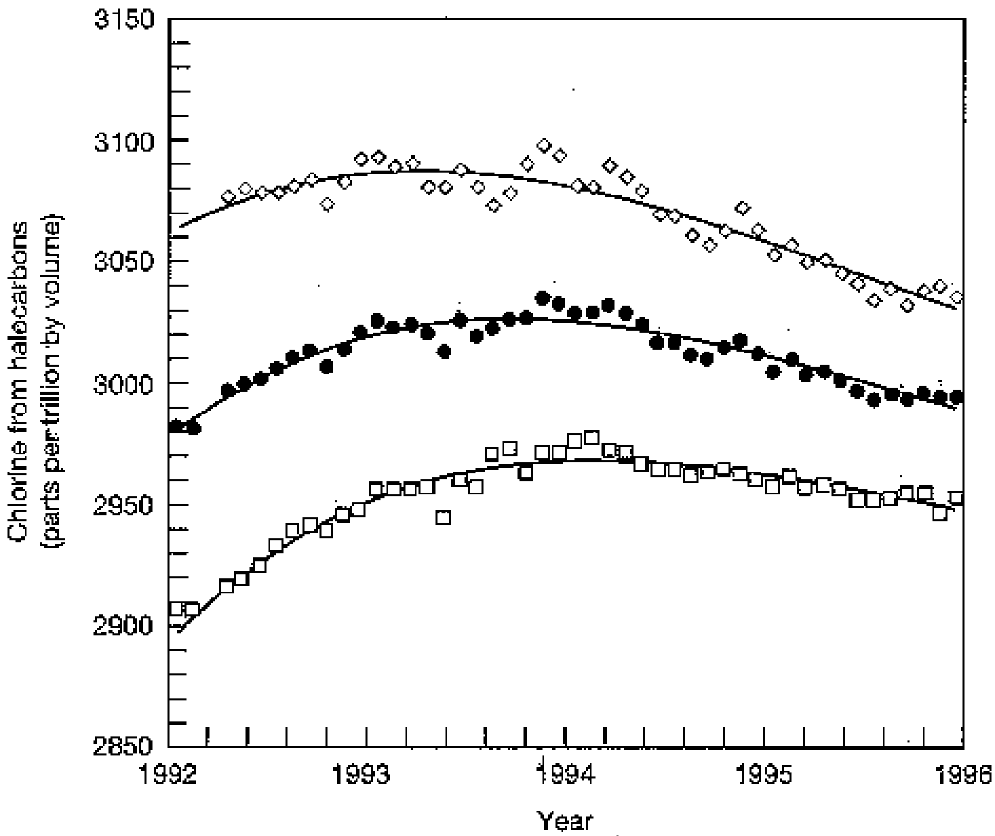
There is, however, some good news in this story, news that should be considered very important from the environmental security standpoint because it proves that global environmental problems can be resolved at the international level. As the scientific understanding of the causes of ozone depletion and its consequences developed within the inter-

[21] de Nevers, 526.

national scientific community, and as people came to realize that the technical solutions needed to reduce dependence on ozone depleting substances existed, the world was able to reach agreement in the Montreal Protocol of 1987 to phase out the use of CFCs. Figure 3-11 provides a graphic depiction of the fact that the chlorine concentrations in the atmosphere have indeed begun to decline. However, the long residence times of many of the different ozone depleting compounds suggests that full recovery will not occur until well into the next century.

FIGURE 3 – 11

Chlorine in the Upper Atmosphere



□ = Measured in Southern Hemisphere

• = Measured in Global Average

◊ = Northern Hemisphere

SOURCE: Fred T. Mackenzie, *Our Changing Planet* (New Jersey: Prentice Hall, 1998), 414.

Impacts of Ozone Depletion

There is certainty that a reduction of the stratospheric ozone layer has a direct impact on the quantity of UV light reaching the ground. All research to date strongly suggests that environmental harm, such as damage to DNA material in organisms, is occurring in areas under the existing ozone hole. In the inhabited areas under the Antarctic ozone hole, southern South America and Australia, biologists are documenting damage to light sensitive plant and animal species. The strategic implications of this issue will be analyzed in Chapter 4.

3.3 Land Use

3.3.1 Deforestation

This section deals with the relationship between the reduction in the amount of forest area in the world and environmental security. On a global scale, forests are important for the uptake of carbon dioxide as part of the global carbon cycle, which then serves to regulate the greenhouse effect. This alone would be sufficient reason to consider the security implications of deforestation, but there are more direct issues that result from the widespread loss of forest areas in a region. Before discussing the impacts of deforestation, it is necessary to look at exactly what deforestation is and where and why it is occurring.

Explaining deforestation begins with a definition of the term "forest." As defined by the Food and Agriculture Organization of the United Nations (FAO), a forest is an area where the tree crowns cover at least 20 percent of the surface area in a developed country and 10 percent of the surface area in a developing country. There is no scientific basis for defining a forest in terms of the economic state of a country, but it is necessary to defer to this definition because the FAO has the best available worldwide data on the state of the world's forests and these data apply this definition.[22]

Scientifically, there are many ways to classify forests. Different forest types are identified by their requirements for temperature, soil types, and moisture. For example, Alan and Arthur Strahler in their physical geography text divide forests into six separate classifications.[23] Because data describing deforestation are not available at such a level of detail, this

[22] FAO, *Forest Resources Assessment 1990: Global Synthesis,* as reported at: www.igc.apc.org/wri/wr-96-97/lc_ttxt2.html, April 2000.
[23] Alan Strahler and Arthur Strahler, *Introducing Physical Geography* (New York: John Wiley, 2000), 207-216.

analysis will consider forests as either temperate or tropical. Figure 3-12a depicts the worldwide distribution of forests and highlights regions of tropical growth climate with a rectangular box across the center of the figure. These classifications generalize the effects of temperature and moisture based on the latitude of the region, but cannot deal with localized impacts, such as altitude.

Tropical forests, located in the wet, always warm mid-latitude belt centered around the equator, occupied 1.8 billion hectares in 1990.[24] As seen in Figure 3-12a, nearly all tropical forests in the world today exist in the developing countries. These forests include both the rainforests with constant leaf cover and monsoon forests that lose their leaves in a dry season. Rainforests, which have literally thousands of species per hectare, are the most biologically diverse biome on Earth. Because of the thickness of the vegetation and the perennial biological activity, tropical forests are the world's most productive regions for removing carbon dioxide from the atmosphere.

Temperate forests contain a much wider variety of both deciduous and evergreen forest types and cover a much larger area of the world, 2.4 million hectares as reported in the FAO 1990 study.[25] Temperate forests contain both deciduous and evergreen species of trees capable of survival in all but the coldest and/or highest altitudes in the world. Though not as productive in carbon cycling or as diverse in species as tropical forests, temperate forests have the ability to propagate over large areas of the world, thus making them a critically important worldwide resource.

Deforestation, throughout time, has been the most fundamental and ongoing action of human modification of the environment. Trees are removed to clear land for farming, to provide lumber for building and energy for heating, cooking, and many economic activities. In a sense, a primary difference between developed and developing countries is that developed countries have reached equilibrium with respect to their renewable forest resources while developing countries continue to reduce forest areas.

Deforestation is defined by the FAO as the loss of tree cover to below 10 or 20 percent crown coverage. On the basis of this definition, Figure 3-12b shows the rate of worldwide deforestation for 1980–1990. It is important to point out, however, that Figure 3-12b depicts as areas of stable growth some areas without forests. Mongolia, for example, is shown as stable in rate of deforestation in Figure 3-12b, but, as seen in Figure 3-12a, there are few existing forests to cut. This fact requires caution in the use of these data.

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[24] FAO, *Forest Resources Assessment 1990: Global Synthesis.*
[25] Ibid.

FIGURE 3 –12a

Distribution of Forests Worldwide

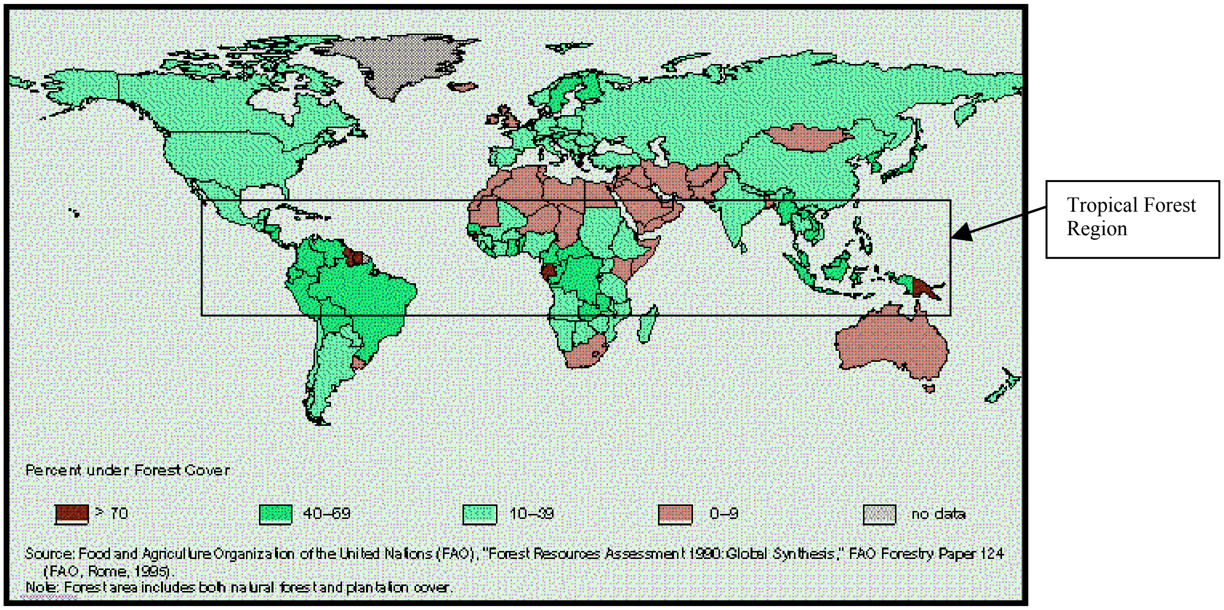
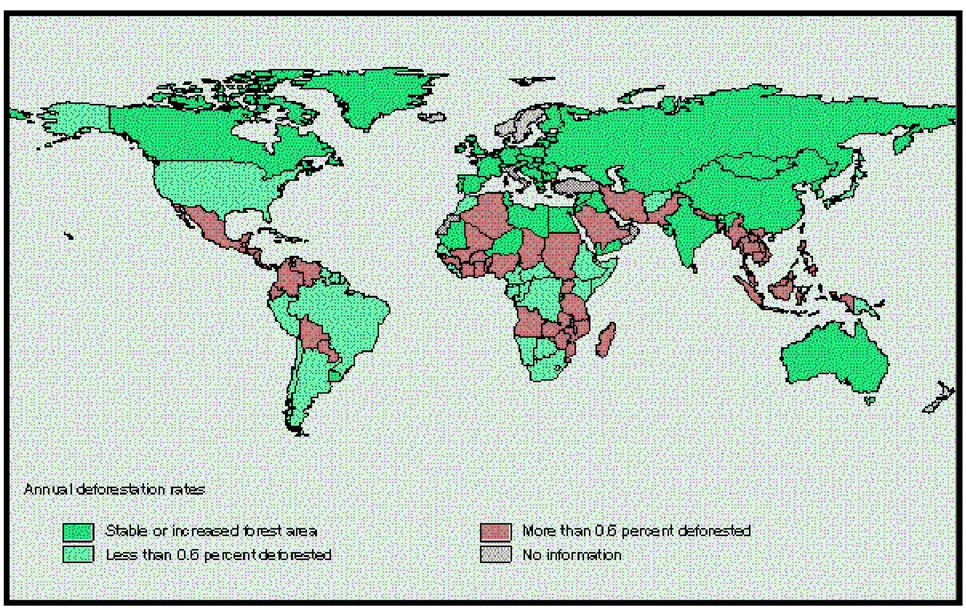


FIGURE 3 – 12b

Estimated Annual Deforestation Rates, 1980-1990



SOURCE: FAO, *Forest Resources Assessment 1990: Global Synthesis,* as reported at: www.igc.apc.org/wri/wr-96-97/lc_ttxt2.html, April, 2000.

Figure 3-12b indicates that deforestation is occurring at the highest rates in the developing countries and within the tropical forests. In contrast, over the period 1990–1995, developed countries showed a net growth in forest area of 0.12 percent per year.[26] Some caution must be taken when considering this number, because it hides a loss in natural forest. In the FAO data calculations, losses in natural forest can be compensated for by increases in plantation acreage. This same source reports the total annual deforestation percentage in the tropics as 0.8 percent or 15.4 million hectares lost per year from 1980 to 1990 (that is an area about the size of the state of Georgia each year).

Deforestation has both a natural component and one of anthropogenically induced change; the discussion here is limited to the latter. In the developing countries, trees are removed to expand farm and grazing lands, provide fuel wood, and obtain the economic benefits of logging. Population pressure is a direct and acute factor affecting the rate of deforestation for the first two purposes. The need for more land for food production is the obvious driver, but with 35 percent of the world's population relying on wood for cooking and heating—and most of these people in areas without good options to replace wood fuels—the pressure is doubly intense.[27]

Economically, trees are a primary export for many of the developing countries, particularly in the tropics. Logging may be conducted by the government or by international logging companies working under some contractual arrangement with the government. For many of these countries, the profits from logging are essential to help pay the costs of modernization and, in many cases, the costs of a growing and urbanizing population.

It should not be overlooked that most of the wood generated from logging in developing countries is utilized by developed countries. The FAO deforestation data indicate that developed countries have reached a sustaining level in forest management, but the reality is that they are maintaining their forests by satisfying their need for wood from the forests of the developing countries. Japan, for example, a country with more than 60 percent forest cover and showing no net change in forest area, annually consumes 50 percent of all tropical wood cut.[28]

In the developed countries, deforestation results from economic pressures to sustain an often-dying logging industry, but it is further exacerbated by the impacts of air pollution. Air pollution not only kills trees directly, but also can damage trees by making them more susceptible to insect and microbial infestation, which eventually leads to die-off. The damage

[26] Fred T. MacKenzie, *Our Changing Planet* (New Jersey: Prentice Hall, 1998), 254-257.
[27] Ibid., 267.
[28] *World Resources 1996-1997,* www.igc.apc.org/wri/wr-96-97, 217.

that emissions from large power plants cause to forests in the eastern United States is well documented; many regions in central Europe are experiencing similar problems.[29]

In both developing and developed countries, global climate change may affect the size and distribution of forests. Over time, climate change can impact temperature, the quantity and temporal distribution of water, and soil structure, all of which help determine the type of vegetation, including forests, that an area can naturally sustain. The facts are irrefutable; however, actual regional impacts are very difficult to differentiate from naturally occurring change and, therefore, are difficult to predict.

Impacts of Deforestation

The impacts of deforestation range from the very subtle changes in climate that loss of forest areas may induce to the dire life-threatening issues that the absence of fuel wood can cause. In the context of environmental security, consider the examples of Ethiopia and Haiti. In 1900 Ethiopia was 45 percent forested,[30] while today only 2.5 percent of the country remains forest and woodland.[31] Likewise, Haiti has gone from a mostly tree covered to a nearly barren landscape. The strategic discussion of linkages between security and environment are the subject of the next chapter, but it is reasonable to surmise that there is a correlation between the unrest in these countries and these drastic changes in their environments.

Deforestation is not a completely anthropogenic process. Natural changes in climate and weather, forest fires and forest disease all occur at natural rates, producing changes in the types and locations of the world's forests. By observing natural changes, we can get a better understanding of how human-induced deforestation will impact an area. There is no question that numerous serious consequences will result from deforestation. In relation to environmental security, the most critical concerns are:

- Reduced carrying capacity of the land
- Fewer forests as a component of the carbon cycle, resulting in loss of CO_2 removal capacity
- Loss of biodiversity with all of its known and unknown implications

[29] MacKenzie, 327.
[30] Ibid., 257.
[31] *World Resources 1996-1997,* 216.

- Increased flooding and loss of soils, with resultant mudslides and waterway siltation
- Lost economic benefits from loss of forests as a renewable resource

It is well beyond the scope of this paper to discuss the scientific basis for each of the complex concerns attributed to deforestation. In an effort to summarize these concerns in a format that will support strategic analysis later, Table 3-4 describes the possible impacts of deforestation on tropical and temperate regions of the world, further divided into developed and developing countries. In each of the impact boxes, an arbitrary qualitative rating has been assigned based on the severity of impact should deforestation continue at the rates predicted in Figure 3-12b.

What is clearly evident in the table is that the impacts from deforestation will be most severe in the tropical regions, not unexpectedly because these are the regions of highest deforestation rates. It appears the tropical regions are trading short-term economic benefits for an unknown future. From a world perspective, the developed countries share a portion of the blame for global climate change caused by tropical deforestation because they provide the markets for the wood being harvested at a rate much faster than it is being regenerated. Furthermore, developed countries understand how good management practices would allow trees to be harvested without the damage done by large-scale clear cuttings, but pursuit of higher profits by international business is hindering the use of best forestry practices.

When considering security issues in the developing temperate forest countries, impacts on carrying capacity have the most direct and dire effects. In the developing world, the land must provide water, food, and energy for heating and cooking. Loss of fuel wood reduces the ability to properly process food, and this could lead to both malnutrition and disease. Thus, the clearing of former forestlands for grazing and farming can have effects opposite to those intended.

In many parts of the world, forests are the only appropriate use for the land because of shallow soils and high rainfall rates. Removing the trees destroys the root structure that holds soil, thus increasing the intensity of the runoff and causing the soil to be quickly eroded and washed away. In addition to affecting rates of storage of rainfall, deforestation has other detrimental effects on regional hydrologic cycles, with a net effect of less available water over time.

TABLE 3 – 4

Potential Impacts of Deforestation

Possible Issues	IMPACTS Tropical, only Developing Countries	IMPACTS Temperate, Developing Countries	IMPACTS Temperate, Developed Countries
Carrying Capacity - Loss of soil from erosion - Less fuel wood - Less water available - Loss of soil moisture for crops - Land cannot sustain crops	- Increased disease - Food production reduced - Famine - Drought/flooding - Population migrations - Reduced water supply {MODERATE}	- Loss of fuel wood increases disease - Reduced water supply - Reduced soil moisture impacts food supply {HIGH}	- Water supply reduced - Soil moisture loss reduces food production {SMALL}
Carbon Cycle / Global Climate Change - Global warming - Storm frequency and intensity - El Niño / La Niña - Sea level rise	- Less Carbon dioxide absorption - Slash and burn releases carbon dioxide inputs - Change in evaporation rates causes shifts in water availability - Storm frequency impacts - Loss of farmlands {MODERATE}	- Population migrations - Lower soil moisture in growing season - Higher temperatures impact health {HIGH}	- Storm frequency impacts - Minor impacts and shifts in land use {MODERATE}
Biodiversity - Loss of species - Loss of habitat	- Thousands of species lost each year - Critical habitat lost - Loss of indigenous native tribes {HIGH}	- Species die-off - Habitat lost for endangered species {SMALL}	- Loss of natural forests could impact a number of species {SMALL}
Hazards - Loss of life - Increased disease - Economic costs of response	- Increased runoff rates produce floods - Mudslides and siltation of streams {MODERATE}	- Increased flooding damage - Loss of life - Drought more common {MODERATE}	- Increased storm frequency {SMALL}
Economics - Short-term cost/benefits - Long-term costs/benefits	- Debt payment possible - Development funds created - Long-term loss of sustainable resource - Unknown value of biodiversity lost {HIGH}	- Long-term loss of sustainable resource {MODERATE}	- Mitigation of storm impacts - Quality of life impacts {SMALL}

HIGH - Potential to significantly alter existing environmental setting
MODERATE - Measurable negative impacts expected
SMALL - Small net change in environmental conditions, well within capacity for adjustment

3.3.2 Desertification

Today, some 40 percent or 60 million square kilometers of the world's land area is classified as having a dry climate, with some 10 million square kilometers of this land being considered desert.[32] Figure 3-13 represents the distribution of desert areas across the world.

This paper defines "desertification" as the process whereby both water and soil become scarce to the point of being unable to sustain a vegetative cover. The process has both natural and human causes. In the scientific literature, the precise terms used are "desertification" when the process has human causes and "desertization" when the causes are natural. Since this paper is most concerned with human-produced changes, we will use the term "desertification."

When desertification occurs, the loss of vegetative cover allows for increased soil erosion, primarily by wind, further reducing the carrying capacity of the land, even if water were again to be available. Natural fluctuations in rainfall can change the shape of a desert, usually working around the boundaries of an existing desert. Overgrazing, mining of groundwater, and overuse in farming can also produce desertification of an area.

The African Sahel is the most striking example of desertification or land degradation seen in modern times. The Sahel is the belt that extends across Africa at about 15 degrees north latitude and forms the southern extent of the Sahara desert. An increase in the nomadic herding population of the region in combination with a drought lasting from 1968 to 1991 has produced desertification in the area.[33] Desertification has resulted in a drastic reduction of regional grazing capacity until conditions and time allow regeneration of the vegetative cover, if erosion and the other impacts of desertification have not been so severe as to irreversibly damage the land.

Global climate change can produce desertification in the same way that natural climate change does. A major challenge today involves distinguishing natural desertization from human-induced desertification; even more difficult is predicting the changes resulting from the enhanced greenhouse effect. Based on experience to date, we can expect that changes will occur within existing dry climates and on the margins of existing deserts. In some places the result may be a receding of the existing desert because of increased rainfall, while in others the result is likely to be desertification.

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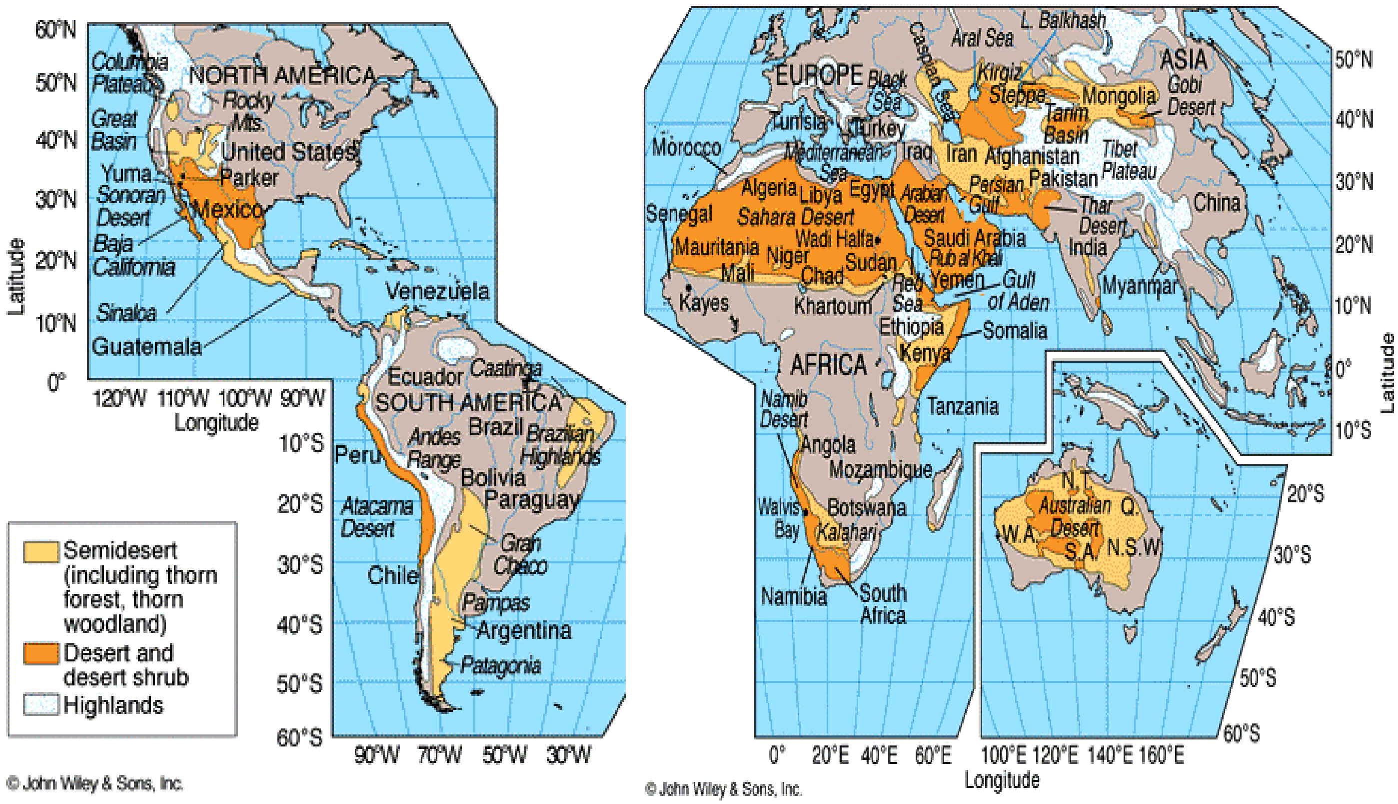
[32] Houghton, 101.
[33] Stahler and Strahler, 170.

FIGURE 3 – 13

Desert Regions of the World



SOURCE: Alan Strahler and Arthur Strahler, *Introducing Physical Geography,* Visualization- Version 2.0 (New York: John Wiley, 2000).

Impacts of Desertification

The ultimate direct impact of desertification is the complete loss of carrying capacity of an already fragile biome, and the primary indirect effect is the migration of people previously supported by that area. Our ability to predict desertification is limited by our inability to predict long-term natural regional climate patterns. Adding to the problem is our lack of understanding of the impacts of anthropogenically induced global climate change, primarily from the enhanced greenhouse effect.

Expansion of the world's deserts will be at the expense of steppe-type environments, which have grass and scrub vegetation and most commonly support sparsely populated herding cultures. Variations in migration and settlement patterns for these people make it difficult to determine the impacts of desertification on humans. More human pressure in these regions could accelerate the desertification process because of increased grazing and fuel wood gathering. Overall, the spiraling impact of desertification displacing people has been seen in the Sahara regions already and it has the potential to affect other parts of the world as a result of global warming.

3.3.3 Hazardous Waste Disposal

Toxic and hazardous materials are a uniquely modern reality. Today, millions of tons of thousands of different chemicals are manufactured for some "beneficial" use. These organic and inorganic chemicals have become ubiquitous throughout the world. Most of these chemicals and the billions of pounds of waste generated as by-products in their manufacturing processes are toxic, carcinogenic, mutagenic, or teratogenic, making their use and disposal hazardous to living organisms. Many of these chemicals biodegrade very slowly, and therefore, when released into the environment, they have the capacity to cause harm for a long time.

The sequence of events that can to lead to environmental damage and human harm is as follows: (1) the intentional or accidental release of these chemicals; (2) human exposure through direct contact, ingestion of contaminated food or water, or inhalation of airborne chemicals; and finally; (3) accumulation of enough of the toxin to produce a physiologic response.

A widely known environmental contaminant, PCBs (polychlorinated biphenyls), can be used to illustrate the hazards posed by modern chemicals. PCBs are a group of organic

chemicals long utilized as insulating fluids in electrical devices because these chemicals possess the appropriate electrical properties while not being volatile or flammable. Over the past 50 years, nearly all large transformers installed on electrical poles and in substations have been filled with this pale yellow liquid.

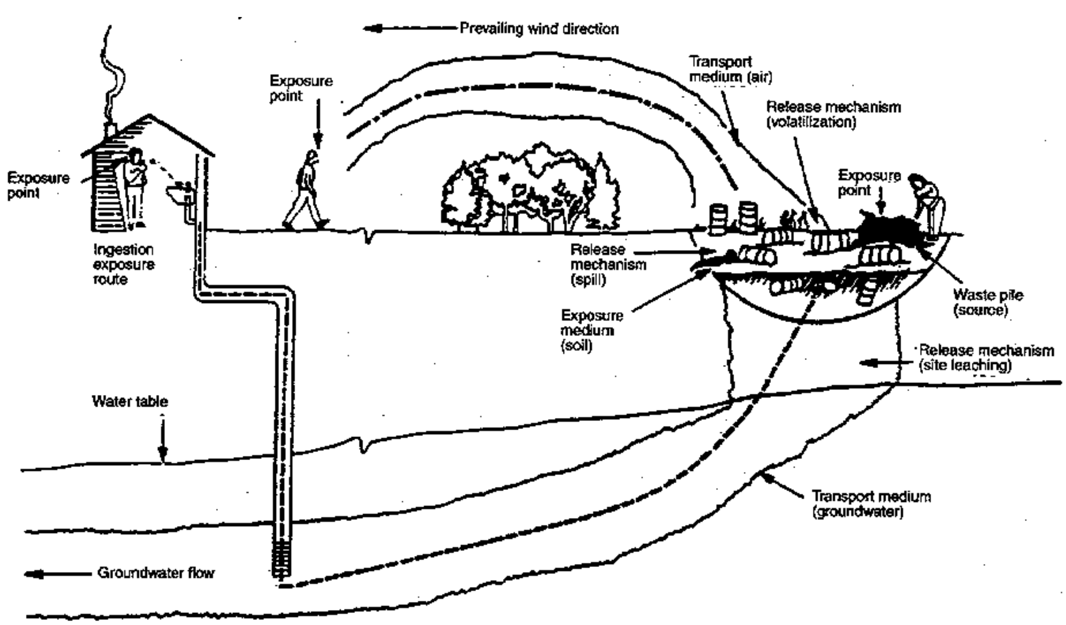
Using PCBs as an example, we can examine the sequence of events outlined above.

Step 1 — As a result of maintenance activities, accidents causing spills, and improper disposal activities, a large quantity of PCBs are released to the environment over many years. Also, PCB manufacturing waste by-products are disposed of in ways that contaminate soil and drinking water supplies. In just one case, a large manufacturing operation dumped thousands of tons of PCBs into the Hudson River in New York State. As a result, the fish in the river today remain dangerous for human consumption years after dumping has ceased.

Step 2 — The pathways through which chemicals released to the environment reach humans are illustrated in Figure 3-14.

FIGURE 3 – 14

Pathways of Human Exposure to Hazardous Substances



SOURCE: W. C. King, *Environmental Engineering* (AAEE, Annapolis, 1999), 436. USEPA 1989.

The most common exposure pathway is through a drinking water source, where contaminants can collect and be transported to unknowing consumers. The figure depicts the drinking water source as a water well, but it is more often a public water supply system. For most of the chemicals that dissolve in water at harmful levels—and this a large number of chemicals—standard drinking water treatment practices DO NOT remove the toxicity. Public water supplies in the U.S. are monitored for hundreds of common contaminants to prevent and protect against these types of problems. However, with thousands of existing chemicals and more being created every day, it is possible for many toxins to go undetected. In the developing world, monitoring involves an expense that typically cannot be afforded.

Step 3 — Except in the case of a catastrophic occurrence, such as the one in Bhopal, India, where thousands were killed or injured from a toxic cloud, most toxins act in an insidious manner, requiring long periods of time for the body to accumulate sufficient concentrations to manifest symptoms. In the case of human beings exposed to contaminated water, food, or air, this time is available. PCBs have an **I**mmediately **D**angerous to **L**ife or **H**ealth (IDLH) level of 5 milligrams per cubic meter (mg/M^3),[34] because of their known carcinogenic risk. This extreme toxicity is further exacerbated by the long persistence of PCBs in the environment.[35] PCBs ingested in water or fish can accumulate in the body until, often decades later, cancer results.[36]

The military has its own unique hazardous materials that have the potential to pollute the environment. These include explosives and weapons materials, waste oils, fuel from spills, waste cleaning solutions and other maintenance fluids, chemical agents, and nuclear material. The DOD now spends billions of dollars a year to clean up past indiscretions in disposal and spillage of hazardous materials. Chapter 4 discusses opportunities to share lessons learned with other military forces, so that they do not make the same costly mistakes or can benefit from U.S. experience to expedite remediation efforts.

Hazardous Waste Issues

Hazardous waste issues all relate directly or indirectly to human and environmental health. Just as Chernobyl made thousands of square kilometers uninhabitable for years, toxic releases from industrial manufacturing and waste dumping directly impact people all over the

[34] NIOSH, *Pocket Guide to Chemical Hazards* (Washington, D.C.: U.S. Public Health Service, 1990), 68.
[35] C. W. Fetter, *Contaminant Hydrogeology* (New York: Macmillan, 1993), 301.
[36] Figure 3-18 explains the process of environmental contamination on the basis of disease transmission.

world. This occurs primarily through pollution of groundwater, making it dangerous to drink. In the developed world this water would not be consumed or would be treated to safe standards. However, in the developing world, conditions are such that contamination may not be detected, there may be no alternative source of drinking water, or treatment may be too expensive—all of which adds up to an extremely hazardous situation for people in the developing world.

Air exposures to toxic chemicals occur in the developing world where modern pollution abatement technology is not applied to industrial smokestacks. A senior Russian environmental scientist in 1995 reported areas of his country where the infant mortality rate had reached 50 percent because of toxic metals released to the air from smelting operations.[37] Land use for farming and living can also be degraded or lost as a result of toxic contamination events. Overall, toxic pollution can severely stress people and the environment, and may pose a threat to the security of a region.

3.4 Water Use

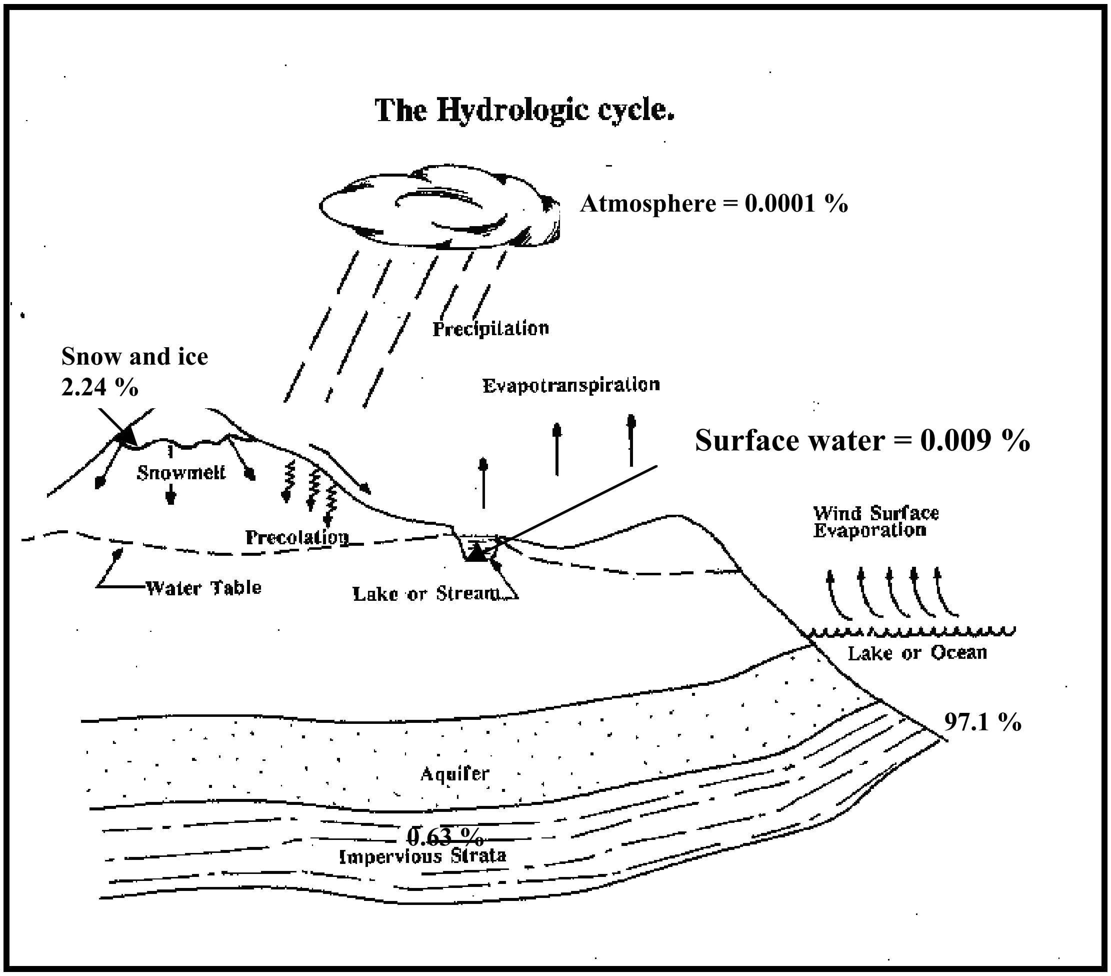
3.4.1 Fresh Water

Water is a critical resource for life and essential for economic success in a modern developed society.

Most people are familiar with the hydrologic cycle depicted in Figure 3-15, which shows the relative quantities of water stored in different segments of the environment. This figure is a good reminder of the relatively small quantity of fresh water available for many demands—domestic consumption, sanitary use, industrial use, electric power generating cooling water, hydroelectric generation, and agricultural irrigation. Water quantity can be measured in terms of total demand, but is better represented in terms of the quantity per person over some period of time (daily or yearly). Figure 3-16 shows world water consumption over the past century in both of these units of measure. Clearly, the eight-fold increase in total water demand is driven by population increases, but demand per person has also doubled over the century.

[37] Non-attribution lecture by a member of the Russian Academy of Science at the United States Military Academy, 1994.

FIGURE 3 – 15
Distribution of Water in the Environment



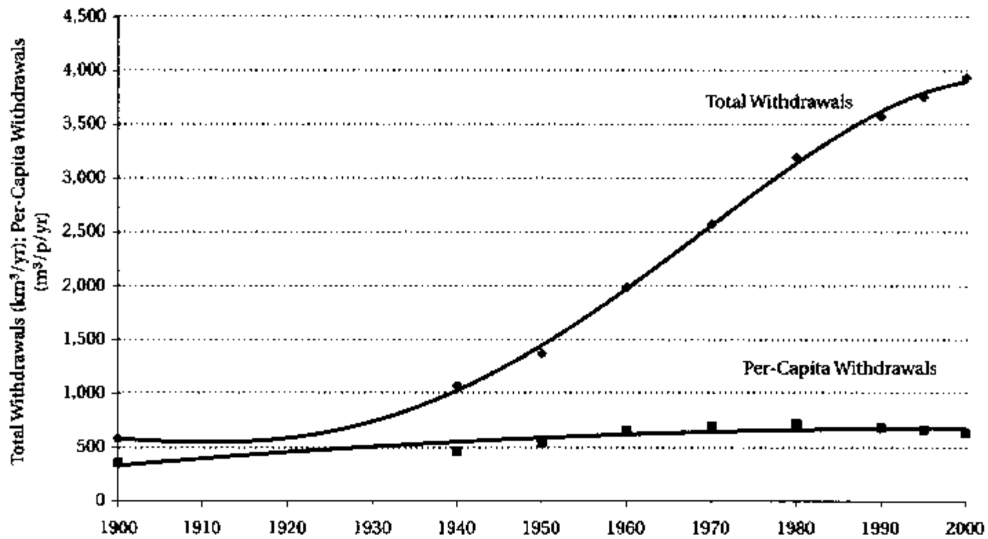
SOURCE: Andrew Dzurik, *Water Resource Planning* (Savage, Md.: Rowman & Littlefield, 1990), 13.

An example of the impact that development has on water use can be seen by comparing water use in the U.S. with world water use. In 1900, world demand was approximately 300 cubic meters per person per year (M^3/p/yr) while in the same units U.S. demand was 700. In 1980, world consumption had grown to 700 M^3/p/yr, while in the U.S. demand had reached 2700 M^3/p/yr. In terms of these units, which factor population growth out of the equation, water demand in the U.S. had grown by a factor of four while world demand had increased by a factor of only two.[38] The important point here is that transforming from a developing to a developed society, to this point in history, has greatly increased the requirement for water.

[38] Peter Gleick, *The World's Water* (Washington, D.C.: Island Press, 1998), 10-13.

FIGURE 3 – 16

World Water Use Rates, Total and Per Capita



SOURCE: Peter Gleick, *The World's Water* (Washington, D.C.: Island Press, 1998), 11.

The problem is one of trying to reconcile supply (Figure 3-15) with demand (Figure 3-16). Supplies are fixed, while demand continues to grow rapidly. There has been progress in improving management practices, but these have reduced the rate of growth in demand per person, not total consumption. In this context, the U.S. can be considered a recent good news story. By 1995, demand in the U.S. had dropped to 2,200 cubic meters per person per year, resulting in a flattening of total demand over the past 20 years. This was achievable only in concert with a small population growth rate over the same period.

The bottom-line for water as a resource is:

- Demand will continue to increase steadily and in direct proportion to population growth.
- Modernization (development) will increase demand, not reduce it.
- It can be expected that, in areas experiencing water shortages now, conditions will worsen, while many more areas of the world will reach their limits of available water resources.

Figure 3-15 shows that water resources are renewed by precipitation which recharges surface water streams and lakes and water stored in the ground. This recharge is temporally

and spatially dependent, or, in simpler terms, we don't have water problems—it just comes in the wrong places at the wrong times. To overcome this problem, dams are constructed to store water for use during drier periods and aqueducts are built to transmit water to areas without sufficient resources to meet their demands, but these mitigative actions are less than fully effective. Dams are expensive solutions; they have limited life spans and are feasible only in ideal circumstances of available space, high seasonal flows, and no conflicting water uses. Aqueducts are also expensive, requiring that some region be willing to supply water to another region and that access between the two areas can be assured. In a military context, there is some concern about the security issue of having water supplies that are vulnerable to the actions of others or can serve as a possible critical target in a conflict.

In terms of environmental security, an important question is: what is the basic water requirement for a person to sustain life? This value must include water for drinking, cooking, and basic sanitation requirements such as personal hygiene and cleaning. One widely accepted estimate is 50 liters per day per person.[39] Table 3-5 identifies those countries of the world not providing this quantity of water as of 1990.

TABLE 3 – 5

Water Data for Countries with Low Domestic Supplies

COUNTRY	Total Domestic Water Use (Liter/per/d)	Total Water Withdrawal (km^3/yr)	Total Renewable Supply (km^3/yr)	Total Use (M^3/per/yr)	Domestic Use (%)
Gambia	4.5	0.02	8	23	7
Mali	8	1.36	67	148	2
Somalia	8.9	0.81	15.7	108	3
Mozambique	9.3	0.6	216	39	9
Uganda	9.3	0.2	66	11	32
Cambodia	9.5	0.52	498	69	5
Tanzania	10.5	1.17	89	43	9
Central African Rep.	13.2	0.07	141	23	21
Ethiopia	13.3	2.2	110	45	11
Rwanda	13.6	0.77	6.3	106	5
Chad	13.9	0.18	43	32	16
Bhutan	14.8	0.02	95	15	36
Albania	15.5	0.2	21	94	6
Zaire	16.7	0.36	1019	10	61

[39] Ibid., 44.

COUNTRY	Total Domestic Water Use (Liter/per/d)	Total Water Withdrawal (Km^3/yr)	Total Renewable Supply (Km^3/yr)	Total Use (M^3/per/yr)	Domestic Use (%)
Nepal	17	2.68	170	103	7
Lesotho	17	0.05	5.2	28	22
Sierra Leone	17.1	0.37	160	89	7
Bangladesh	17.3	22.5	2357	211	3
Burundi	18	0.1	3.6	18	36
Angola	18.3	0.48	184	48	14
Djibouti	18.7	0.01	0.3	24	13
Ghana	19.1	0.3	53	20	35
Benin	19.5	0.14	25.8	31	23
Solomon Islands	19.7	0.001	44.7	18	40
Myanmar	19.8	3.96	1082	103	7
Papua New Guinea	19.9	0.1	801	25	29
Cape Verde	20	0.03	0.3	70	10
Fiji	20.3	0.03	28.6	37	20
Burkina Faso	22.2	0.38	17.5	42	19
Senegal	25.4	1.36	39.4	186	5
Oman	26.7	1.22	1	325	5
Sri Lanka	27.6	6.3	43.2	503	2
Niger	28.4	0.5	32.5	65	16
Nigeria	28.4	3.63	280	33	31
Guinea-Bissau	28.5	0.02	27	17	60
Vietnam	28.8	5.07	376	81	13
Malawi	29.7	0.94	18.7	107	10
Congo	29.9	0.04	832	18	62
Jamaica	30.1	0.32	8	157	7
Haiti	30.2	0.04	11	46	24
Indonesia	34.2	16.6	2530	96	13
Guatemala	34.3	0.73	116	139	9
Guinea	35.2	0.74	226	128	10
Cote d'Ivoire	35.6	0.71	78	59	22
Swaziland	36.4	0.66	4.5	830	2
Madagascar	37.2	16.3	337	1358	1
Liberia	37.3	0.13	232	50	27
Afghanistan	39.3	26.11	65	1436	1
Uruguay	39.6	0.65	66	241	6
Cameroon	42.6	0.4	268	34	46
Togo	43.5	0.09	11.5	25	62
Paraguay	45.6	0.43	314	111	15
Kenya	46	2.05	30	85	20
El Salvador	46.2	1	19	241	7
Zimbabwe	48.2	1.22	20	126	14

SOURCE: Peter Gleick, *The World's Water* (Washington, D.C.: Island Press, 1998), 235-244.

Understanding the causes of the shortfall requires analyzing both the available supply and rates of withdrawal and use. First, only a small portion of the annual renewable supply is actually usable in the sense that it is available in the right place at the right time. Analysis even on a country scale may not account for the misdistribution of people and resources. Accepting this shortcoming, Table 3-5 shows the renewable water supply, the total withdrawal per person per year, and the percent domestic use rate. These data will later provide the basis for interpretation of the causes of domestic water shortages in the 50 countries listed in Table 3-5.

Quality is an often-overlooked issue that must be addressed in any discussion of water supply. The World Health Organization estimates that 1 billion people a year contract a water-borne diarrheal disease and that 3.3 million of these people die, per year![40] This does not account for many other water-borne diseases that inflict pain and suffering pandemically throughout the world. A primary quality concern in the developing world is human waste being disposed of in surface waters which contaminate drinking water supplies and this water then being consumed without adequate treatment. The current state of safe drinking water and adequate sanitation in the world is depicted in Figure 3-17. Clean water is a critical issue for parts of South and Central America, most of Africa, and much of Asia.

The developed world is not without its problems with water quality. A water-borne disease outbreak in Minneapolis in 1993 caused over 400,000 cases of disease and 100 deaths, this in a region rich in water resources.[41] While we have the technical capability to treat any polluted water to a standard that makes it again safe for consumption, this technology is very expensive. Great improvements have been made over the past 30 years in safeguarding the developed world's drinking water. In the developing world, however, water-borne disease, toxic waste disposal, and other forms of pollution continue to degrade fresh water resources.

After basic human needs for water are satisfied, other uses for water can be met with the available supplies. These higher-level uses include irrigation, power generation, and the many industrial processes (such as food processing) that are high volume users of water. In Table 3-5, non-domestic use can be determined as the percent difference from the amount shown in the last column. For example, even though Afghanistan and Madagascar fall short of recommended domestic supplies, 99 percent of their total water use is diverted to other purposes; in these two countries this water all goes to agricultural use. One of the great uncertainties relating to global climate change is how weather shifts will impact food production by changing water supplies during growing seasons.

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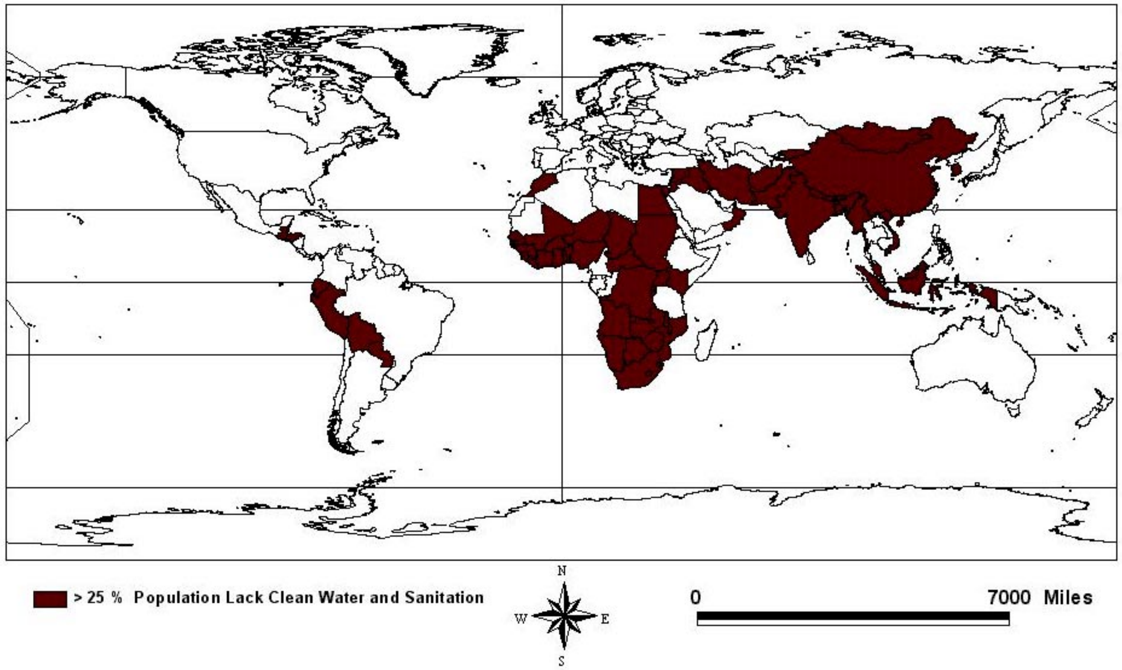
[40] WHO, *Community Water Supply and Sanitation* (A48/EOS/96.15), 48th World Health Assembly, Geneva 1995.
[41] Gleick, 48.

FIGURE 3 – 17

Countries Without Clean Water and Adequate Sanitation



SOURCE: Peter Gleick, *The World's Water* (Washington, D.C.: Island Press, 1998).

Salinity in water is another major quality issue of concern in agriculture and industry. Salts present in irrigation water are retained and concentrated in the soil as water naturally evaporates from the upper layers. Over time, without adequate rain to dissolve these salts back into the water for transport away, salt levels in soil build up to concentrations toxic to many plants. These lands are then lost to production or must be used for crops more tolerant of salt. Such crop choices are quite limited. Salination is reducing food production rates in many parts of the world today, mostly in arid regions where lack of rainfall makes soil recovery times very long. The U.S. is experiencing this problem in isolated parts of the arid West and Southwest.

Overall, water is a problem affecting basic survival in at least one third of the world and a limiting factor in development for most of the world. As an anonymous American sage once said, “People argue over politics; they fight over water.”

Water Scarcity Issues

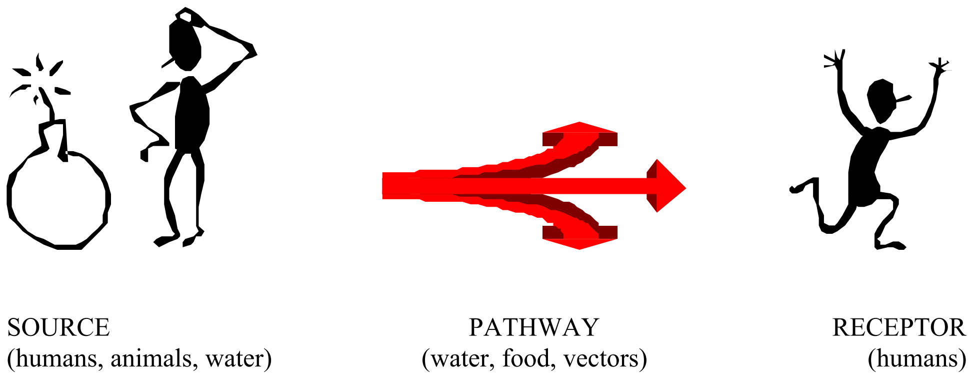
The issues having to do with sufficient quality and quantity of fresh water are obvious, but current and anticipated impacts on the world need to be addressed. Foremost is the impact on health resulting from inadequate and/or contaminated water. This is a two-part problem, the first part being sanitation and the second being clean water sources for drinking.

Nearly all infectious diseases and thus epidemics in the world today have poor sanitation as their root cause. Figure 3-18 presents a description of this process. Human wastes serve as a reservoir of disease. Depending on the disease, the mode of transmission can be water, food, or vectors, but contaminated water is by far the most common vehicle for disease agents. In most of the world, water in open or contained sewers is used to convey human wastes away from susceptible human populations to eventually discharge into the nearest naturally flowing stream. In the developed world, sewage is treated to reduce the level of pathogenic organisms before discharge. In most cities of the developing world, sewage flows, untreated or partially treated, directly into the surface water system. Water scarcity reduces the amount of water available to safely remove the waste from populated areas. This affords exposure opportunities through direct contact with vectors such as flies and mosquitoes transmitting the disease or numerous other pathways for disease transmission.

The second part of this problem has to do with the water supply. In water-scarce regions, all available resources—even those contaminated with human and animal wastes—must serve as human water sources. As noted earlier, the technology exists to clean

FIGURE 3 – 18

A Primer in Epidemic Disease



There has long been a basic understanding of the disease transmission and the epidemic process, as evidenced by guidance on personal hygiene to prevent illness dating back to the Bible and the Koran. Disease is transmitted following the source-pathway-receptor model illustrated above. The source or reservoir is the location of the active disease agent, typically bacteria or viruses. In most cases of infectious disease, humans are the reservoir. "Pathway" indicates that there must be a mode of transmission from the source to the receptor. This is the function that water accomplishes most often, but disease can also be transmitted by food as well as person-to-person contact. The receptor is a person who is susceptible to the contagious agent.

Not all people exposed to an agent will contract the disease; incidence of disease is heavily dependent on the dose received and the susceptibility of the receptor (victim). In disasters where the population has been weakened by malnutrition, stress, and exertion, people are much more susceptible to disease; thus, epidemic diseases following disasters are commonplace. In addition, the breakdown of public sanitation in disaster situations further accelerates disease transmission through the source-pathway-receptor model. Crowding in squalid camps exacerbates the situation by bringing large numbers of susceptible people into close proximity with disease sources and unsanitary conditions. Breaking the disease cycle following natural or human-caused disasters is a difficult problem for the military as we are called to provide humanitarian relief to refugees and displaced people all around the world.

this water to safe standards, but the cost of high technology treatment is out of reach for most developing countries. In fact, much of the world's population uses untreated water directly from the source.

Consider again the example of Minneapolis mentioned earlier in the chapter, the case in which *Cryptosporidium*, a water-borne microorganism transmitted through a treated public water system, killed over 100 people. In the developing world, water-borne cholera, salmonellosis, and *E. coli* are constant security threats. The World Health Organization (WHO) estimates that 2.6 billion people live without proper sanitation, while 1.3 billion people are without safe drinking water.[42] Figure 3-17 shows the areas of the world where more than 25 percent of the population lack proper sanitation and safe drinking water. As the figure makes clear, in terms of both mortality/morbidity and the cost drain of health care for preventable disease, water scarcity can have a debilitating impact in much of the developing world.

As a major contributor to population migration, water scarcity also poses a major threat to security in many regions of the world. The impacts of recurring droughts in Saharan Africa have shown this to the world. Overall, water is a resource essential for food production, power, and transportation, and it is critical for many industries. Because all of these are significantly impacted when water is "shared" by different countries or different peoples, water scarcity is a security issue.

3.4.2 Oceans

The oceans are considered an environmental security issue primarily because of their role in feeding the world's population and the regional economic importance of fishing for some countries. Annual fish harvesting increased from 22 million tons in 1950 to just over 90 million tons in 1995. This was down from a peak harvest of 100 million tons in 1989.[43] There is strong evidence that overfishing in many regions of the world has caused these recent declines. Fish as food now represents 20 percent of the protein consumed by humans and is the primary source of protein for more than 1 billion people.[44] The increased harvesting is caused by the demand as populations grow and by increased per capita consumption of fish as it is substituted for other meat sources that have become more expensive.

[42] Ibid., 40.
[43] Getis, 429.
[44] Ibid., 427.

A secondary impact of the water quality issues described above is damage to estuaries, which causes a reduction in the production of food for the ocean's fauna. Discharge of domestic and industrial sewage into closed waters, the Mediterranean Sea, for example, is also reducing the number of fish in these waters.

4. STRATEGIC ANALYSIS

Today, the United States of America is the world's preeminent superpower, whether military or economic power is used as a measure. The U.S. is also the world's largest consumer of energy and other natural resources, as well as the world's preeminent generator of waste. More municipal solid waste (trash) is produced in the U.S. than the total of the next highest 15 developed countries of the world together.[1]

In negotiating policies for global warming, the United States has attempted all manner of clever data manipulation to hide its rate of consumption of fossil fuels and production of greenhouse gases from the world, but all disguises have failed to conceal the fact that the U.S. is, far and away, the world leader in greenhouse gas pollution, not an admirable achievement (see Table 3-2).

The cartoon in Figure 4-1 really says it all: the fat cat driving the gas hog sits judgmentally over the developing world in "protecting the environment" (cultural illiteracy is also evident). The U.S. still views itself as the good guy trying to do the right thing for the rest of the world—secure peace, ensure a clean environment, and help establish an acceptable quality of life worldwide. People in the rest of the world see the U.S. with less trust, questioning its motivation in helping and supporting them.

This is the context in which the U.S. is searching for a coherent policy and strategy with regard to environmental security. It is critically important to recognize that environmental security is only one component of the larger process of U.S. foreign policy and cannot be separated from the whole. Foreign policy issues are outside the scope of this research, as is much of the detail of how our Department of State should accomplish its environmental security mission. This study limits itself to separating overall requirements into military missions and those governmental actions best accomplished by other agencies.

Recalling the opening questions, it is now time to address:

What is the military mission in environmental security
and how should this mission be executed?

[1] Rodney White, *North, South, and the Environmental Crisis* (Toronto: University of Toronto Press, 1993), 148.

FIGURE 4 – 1

Environmental Security, Two Perspectives

SOURCE: Scott Willis, *San Jose Mercury News,* Copley News Service, 1989.

First, it may be useful to recap what has been discussed to this point. Chapter 1 reviewed current discussions and research regarding the political science of environmental security, while Chapter 2 focused on defining the term "environmental security" and proposed a working definition for this study. Chapter 3 presented a scientific overview of critical environmental issues.

Our strategic analysis begins with a notional understanding of the key environmental security issues and how environmental scarcity and environmental degradation could impact security. To avoid making radical assumptions—and recognizing that there are still many uncertainties—we can draw from the generally accepted lessons of the body of environmental security studies in identifying three consensus-based areas of critical concern:

1. Environmental scarcity is impacting human lives in many regions of the world.[2] In an address to the International Conference on Climate change in 1994, Eileen Claussen, the Senior Director of Global Environmental Affairs for the National Security Council, stated: "The four resources most likely to help produce conflict are cropland, water, fish, and forests."[3] As discussed in Chapter 3, scarcity or degradation of these four resources is often the result of human-induced environmental change.

2. Environmental resource scarcity, fostered by a combination of population growth and resource depletion, has already been a cause or a contributing factor in regional conflict.[4] The conflict in the Sahel region of Africa (Chad, Ethiopia, and Sudan), and the Bangladesh-Assam fighting were resource-depletion based, with resource scarcity driving migration which led to ethnic conflict. The Senegal River conflict and, to many, the genocide in Rwanda also had resource scarcity issues as basic causes.

3. The environmental conditions that sparked the conflicts mentioned above are only getting worse—there is less water and arable land, fish resources are being heavily mined, and deforestation continues—while regional populations burgeon.

The useful scholarly debates concerning the cause and effect relationships between conflict and environmental issues will continue, but our task here requires us to pragmatically move past this discussion. It was earlier stated that this study would employ a risk-assessment model in dealing with uncertainty. This approach allows for making the best possible decisions based not on certainty about what will happen, but on the best scientific judgments on the consequences of what is most likely to happen.

Applying risk analysis to the three areas of critical concern listed above, it can be concluded that the risk of destabilizing events or conflict is high today and can be expected to increase. The resulting harm—which is the threat to long-term U.S. security caused by the occurrence of many of the sufficiently likely conflicts—would be significant. Therefore, following a risk model where magnitude of harm multiplied by the probability of occurrence equals risk, a high potential risk would necessitate a security strategy focusing on preventing and responding to the potential threats to environmental security. This is the approach taken in most aspects of U.S. national security strategy planning: employing a risk-based threat analysis as the basis for decisions on future policy and strategy.

[2] White, *North South, and the Environmental Crisis.*
[3] Eileen Claussen, speech given at the International Conference on Climate Change, Washington, D.C., July 1994.
[4] James Lee, *Inventory of Conflict and Environment* (Atlanta, Ga.: AEPI, 1999).

4.1 Environmental Security Threat Assessment

Analysis of the threat posed by environmental degradation can be simplified into three questions:

What is going to happen?

Where is it going to occur?

When will it start?

What is going to happen was discussed in Chapter 3 and will be summarized in this chapter. ***Where*** these issues are going to occur is the focus of much of the remainder of this chapter, but can be dealt with only on a larger regional scale because of the coarseness of the data available. ***When*** is probably the most difficult of all the issues, because so many variables, natural and human-induced changes, enter into the calculations.

Obviously, the answers we seek are not going to be straightforward. This is compounded by the fact that environmental security is very much a contextual issue. For example, assume that two disputes over water rights exist between the U.S. and Mexico on one border and the U.S. and Canada on the other. If the technical details of these two problems are similar, will the nature of the discussions be the same? Experience supported by numerous examples suggests that scarcity of water in the south would make that dispute much more contentious. Further, the prevailing political environment could make the technical details of the issue secondary to the political policy considerations. To reemphasize a previous statement, *environmental security is only one component of the larger process of U.S. foreign policy and cannot be separated from the whole.*

In strategic decision making, politics has primacy over the military and even science. However, environmental studies do offer solid intelligence data to allow the conduct of an environmental security threat assessment. To begin, Table 4-1, "Impacts of Environmental Change," presents a summary of the information developed in Chapter 3 on the possible impacts of the most significant environmental hazards. Drawing on Table 3-4 (potential impacts of deforestation) and Table 3-3, which predicts regional impacts of an enhanced greenhouse effect, Table 4-1 addresses the "What" component of our analysis and, to a small extent, where these impacts may be expected.

Table 4-1 stratifies the impacts into the categories employed by Ms. Claussen (farmland, forest, water, and fish), with the addition of consideration of human impacts. As we

TABLE 4 – 1

Impacts of Environmental Change

Environmental Issue	Global Environmental Concerns				Regional Environmental Concerns			
	Farmland	Forest	Water / Fish	Human	Farmland	Forest	Water / Fish	Human
Global Climate								
- Warming	Inundation of arable lands, drier soils in summer	Change in shape of temperate and tropical forests	Weather changes impact the hydrologic cycle	Natural hazards, property loss, heating & cooling costs	Wetter wet seasons, drier soils in dry season	Shifts in size and location of temperate and tropical forests	Changes in rain patterns, change in temporal and spatial distribution	Increased disease in developing countries
- El Niño	---	----	---	---	Increased erosion	Change in water distribution	Increased winter rains, loss of fish in Pacific	Flooding and other natural hazards
- Ozone depletion	UV damage to many species of plants & animals	UV damage to many species of plants & animals	---	Cancer	UV damage to many species of plants & animals	UV damage to many species of plants & animals		Cancer in Southern Hemisphere
Land Issues								
- Deforestation	---	Greenhouse gases produced, less CO_2 recycled, loss of biodiversity	Reduction of groundwater recharge, siltation of streams	Indigenous tribes endangered, biodiversity lost	Temporary increase in cropland	Net loss, particularly in tropical forests, Biodiversity loss	Decreased groundwater recharge, increased runoff rates	Loss of Indian habitat in rainforest, loss of beneficial species
- Desertification	---	---	---	Displacement herding populace	Loss of productive lands	Encroachment on fragile forests	Reduced soil moisture, can increase runoff & reduce recharge	Migration of African nomads
- Waste disposal	---	---	Contamination of surface & ground water and fish	Toxic exposure	---	---	Poisoning of water supplies & fish	Toxic exposures; contamination of water resources and food chain
Water								
- Quantity	---	---	Freshwater fish lost, reduced productivity in estuaries	Increased migration	Reduced irrigation and grazing	Highly variable impacts by regions	Freshwater fish lost, reduced productivity in estuaries	Increased migration
- Quality	---	---	Toxicity and bioaccumulation of toxics	Increased rates of disease	Salinity reduces productivity	Acid rain damage	Toxicity and bioaccumulation of toxins	Disease increases in developing countries
- Oceans	---	---	Overfishing is endangering stocks	Loss of fish, disease exposure	---	---	Overfishing is endangering stocks	Loss of fish protein; disease

proceed with our analysis it will become evident that, for military considerations, acute human impacts must be included in the assessment.

Table 4-1 further divides impacts into global and regional, a distinction which is of great importance in identifying the appropriate policy and strategy response. Table 3–4 describes impacts of deforestation on tropical and temperate (i.e., outside 20^{o} latitude north or south) regions of the world and then further subdivides these regions in terms of economically developed and developing countries in temperate regions and developing countries in the tropics (because there are no fully economically advanced countries in the tropical belt). These divisions are similar to the North and South approach of Rodney White[5] and others, which defines the rich northern temperate world as one group and the tropical and southern temperate developing countries as a second group. This study attempts to overcome the shortcoming of the North and South approach by including a separate classification for northern temperate developing countries. For environmental security purposes there are important countries in this classification, such as the Balkans and some of the small states of the former Soviet Union.

Considered together, Tables 3-3, 3-4, and 4-1 permit several summary conclusions to be made about the impacts of environmental degradation and change, including, in order of importance:

1. Humans are threatened by loss of water and food and increased incidence of disease. This is a summary finding based on the human and farmland columns of Table 4-1, but it is supported by the information in Table 3-4. Table 3-3 suggests regions where these impacts are likely to occur; temperate and tropical Asia and Africa appear to be the areas of most concern.

2. The greatest overall impacts from cumulative environmental change will occur in the tropical countries, which are all economically developing countries. All current data and analysis suggest this to be true.

3. Global warming with its linkages to deforestation is the issue with the potential to produce the most damage. Table 3-3 predicts large-scale impacts from global warming and Table 3-4 lists some of the devastating effects that reduced carrying capacity could have in some regions.

4. Weather change is likely to produce an increase in the incidence of natural hazards as increased evaporation is counterbalanced by new, more intense

[5] White, *North South, and the Environmental Crisis.*

weather cycles. Because of environmental degradation, many more people will be at risk.

5. A combination of factors presented in Table 4-1 is resulting in a lessened ability to feed the people of the world.

6. Issues related to water are major stress factors on human subsistence and economic development.[6]

Using the summary data available, we can move on to conduct a geographic information systems (GIS) analysis to determine more precisely "Where" environmental security problems and conflicts may occur. The GIS process is a powerful tool for employing spatial data to identify trends and cumulative factors. The GIS process begins by thematically mapping environmental data at a constant scale, recognizing that edge errors may exist because most data are constructed following political boundaries while the actual issues spill across borders. Information is then overlaid or stacked to identify points of conformity between features or values.

Population density and rate of natural increase[7] are two (of many different) ways of examining population data that will be employed here. In environmental security studies, the only true common ground among researchers is the strong consensus belief that population is a primary variable in understanding all the other issues; therefore, some form of population statistic will always be the base feature.

The first GIS analysis takes the water scarcity data from Table 3–5 and thematically maps it to produce Figure 4-2. Next, the population density data from Figure 3-2 is overlaid onto Figure 4-2 to create Figure 4-3, which depicts the most populated countries with water shortages. An analysis of this figure suggests that the Ganges River region and island nations in southwest Asia are two areas where water is a growing concern. This is a somewhat surprising finding, since these areas fall within the wet tropics. Further study reveals that many factors in combination are creating these regional water supply problems, but the major factor is that the cost of supplying clean water to a fast growing population is beyond the means of the countries of these regions. In many of the island nations, collecting and moving supplies to populated areas is more of the water problem than total available supplies.

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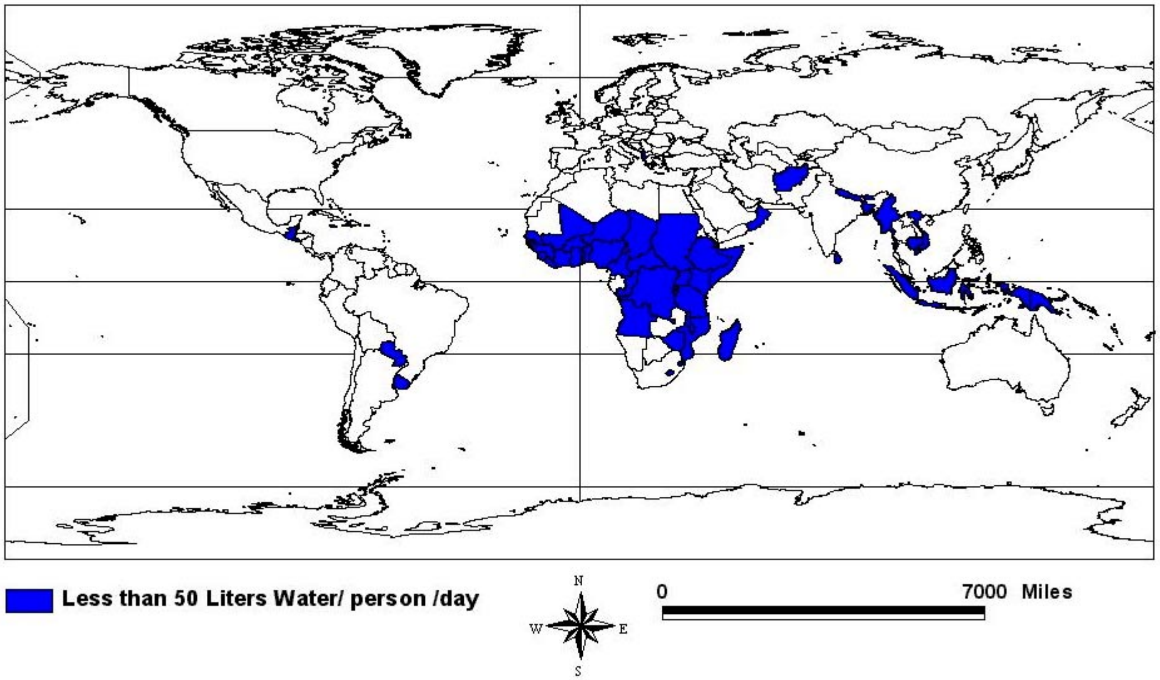
[6] Ambassador Richard Armitage, lecture given at the Naval War College, May 2000.
[7] Rate of natural increase is the crude birth rate minus the crude death rate expressed as a percent value.

FIGURE 4 – 2

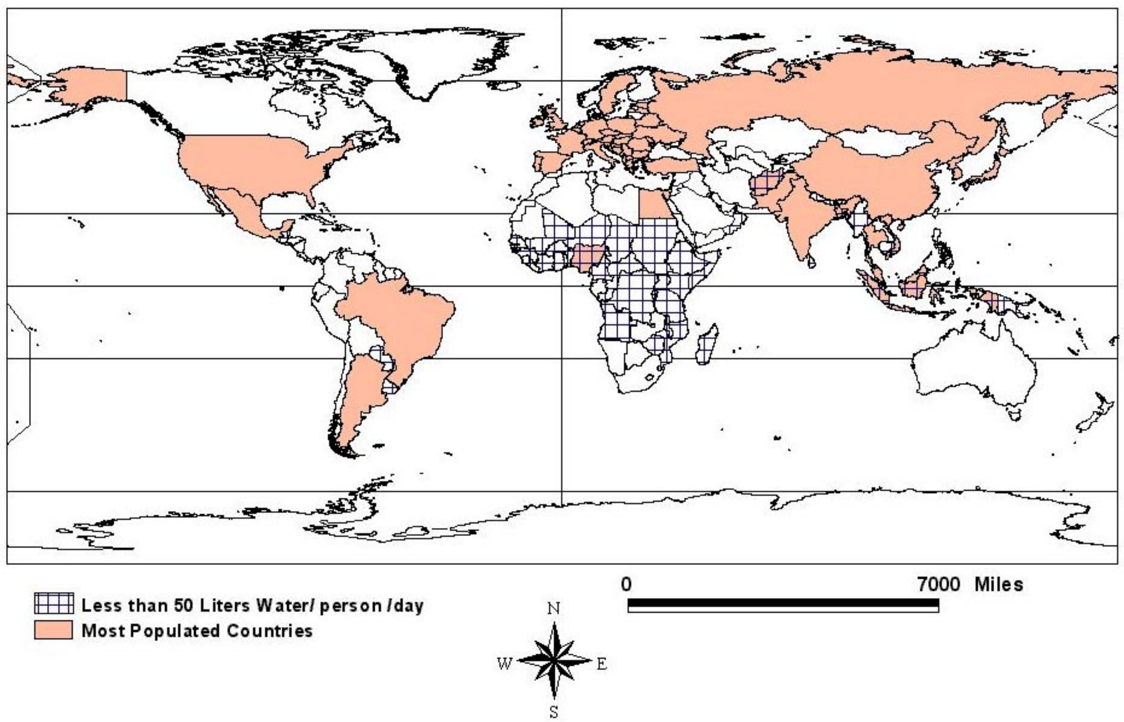
Countries Without Adequate Drinking Water



SOURCE: Peter Gleick, *The World's Water* (Washington, D.C.: Island Press, 1998).

FIGURE 4 – 3

Densely Populated Countries with Water Shortages



SOURCE: Peter Gleick, *The World's Water* (Washington, D.C.: Island Press, 1998); populations from *Goode's World Atlas.*

There is some concern with the analysis depicted in Figure 4-3 because of the lack of correlation between the countries with high population and the countries with water shortages. To address this concern, it was felt that some measure of population growth rate such as rate of natural increase might prove a better metric than population density. To test this theory, the water scarcity data from Figure 4-2 was stacked with the population growth rates data from Figure 3-3 to create Figure 4-4. The result is a much stronger correlation; countries with high growth rates are to a large degree also the countries with drinking water shortage issues. (Doing the same type of analysis with the safe drinking water/adequate sanitation data from Figure 3-17 would further support this finding, but would introduce a separate factor of disease due to the sanitation problems in these same regions.)

We can conclude that population growth rates prove a much better metric than population density in determining the relationship between population and water issues. To further assess the utility of rate of natural increase to predict water scarcity, Figure 4-5 was constructed with only the countries from Figure 4-4 that met both criteria—high population growth rate and water scarcity; *41 of the 50 water-scarce countries also have population growth rates above 2 percent per year.*

Deforestation is another major issue that can be better examined with the help of GIS analysis. Overlaying population growth rates with deforestation rates produces the striking correlation seen in Figure 4-6. *Countries with forests that also have high population growth rates are being deforested at high rates.* The correlation in this case is even stronger than that seen with water. Nearly all of the points of discontinuity can be readily explained. Most are associated with places that have high population growth rates but lack significant forests to cut. Somalia, Ethiopia, and Kenya in Africa and Mongolia in Asia are all examples of this type of situation, as depicted in Figure 4-6. In most of the other cases of discontinuity, the countries had moderate growth and moderate deforestation, with both falling just below the thresholds used in building Figure 4-6.

From a global perspective, our concern becomes the countries in the tropics, Africa in particular, because of the high rates of natural increase. With regard to deforestation, the major concern is with tropical forests because they are the most significant ecological resource. These forests are the most biologically active and thus the most useful in mitigating the enhanced greenhouse effect. In addition, they are 40 times more diverse in species than temperate forests.

The next step in our analysis is to determine which regions of the world will be both water scarce and impacted by deforestation. Figure 4-7 depicts the areas that meet both criteria. The only caution in interpreting these data is that countries already deforested are not

FIGURE 4 – 4

Correlation of Population Growth Rates with Water Scarcity

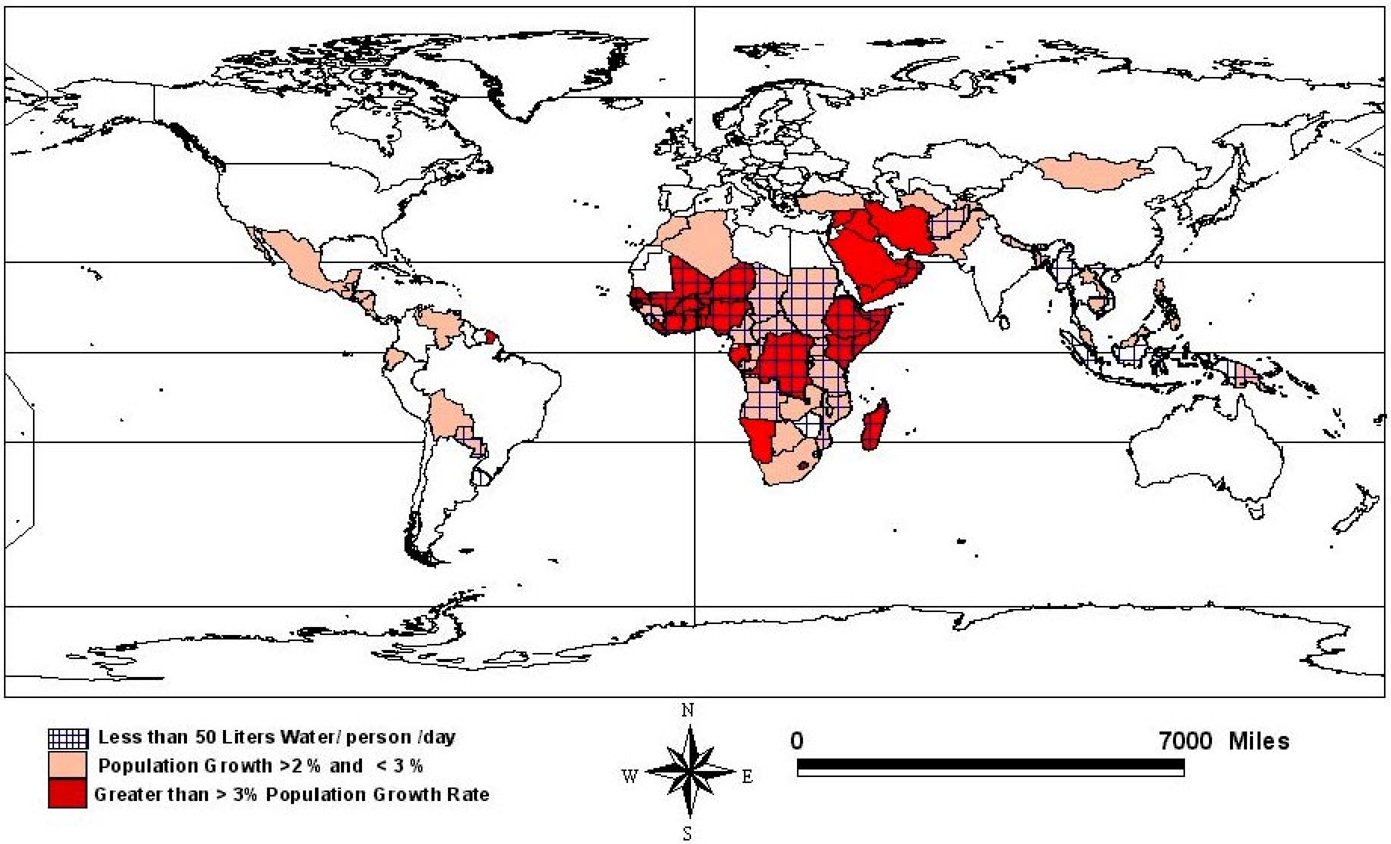


FIGURE 4 – 5

Countries with High Population Growth Rates and Water Scarcity

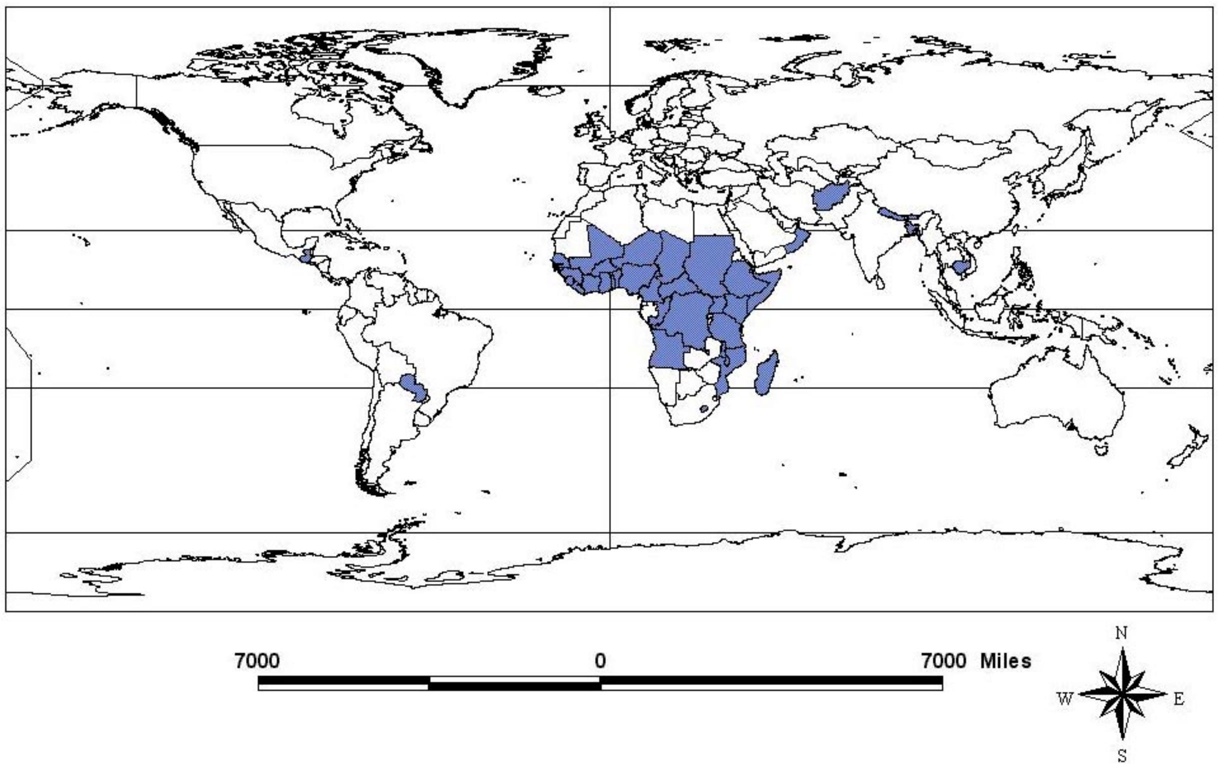


FIGURE 4 – 6

Correlation of High Population Growth Rates with High Deforestation Rates

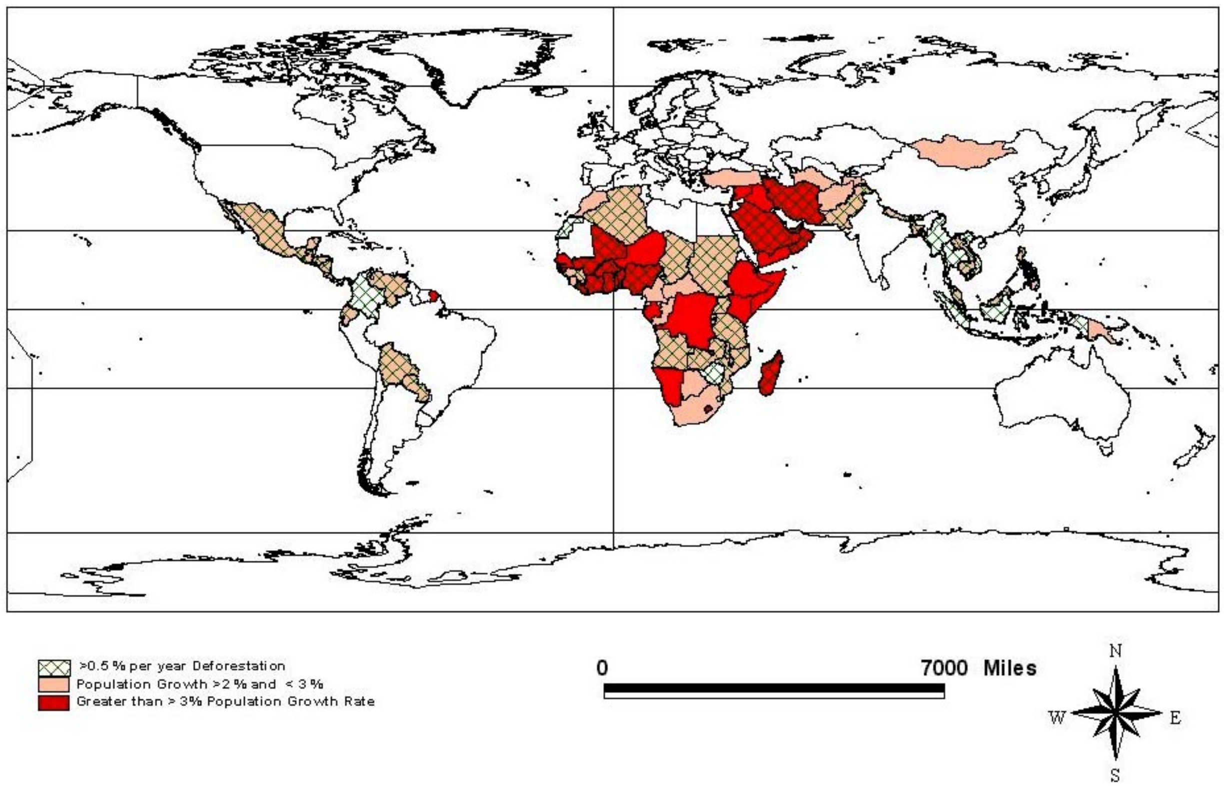
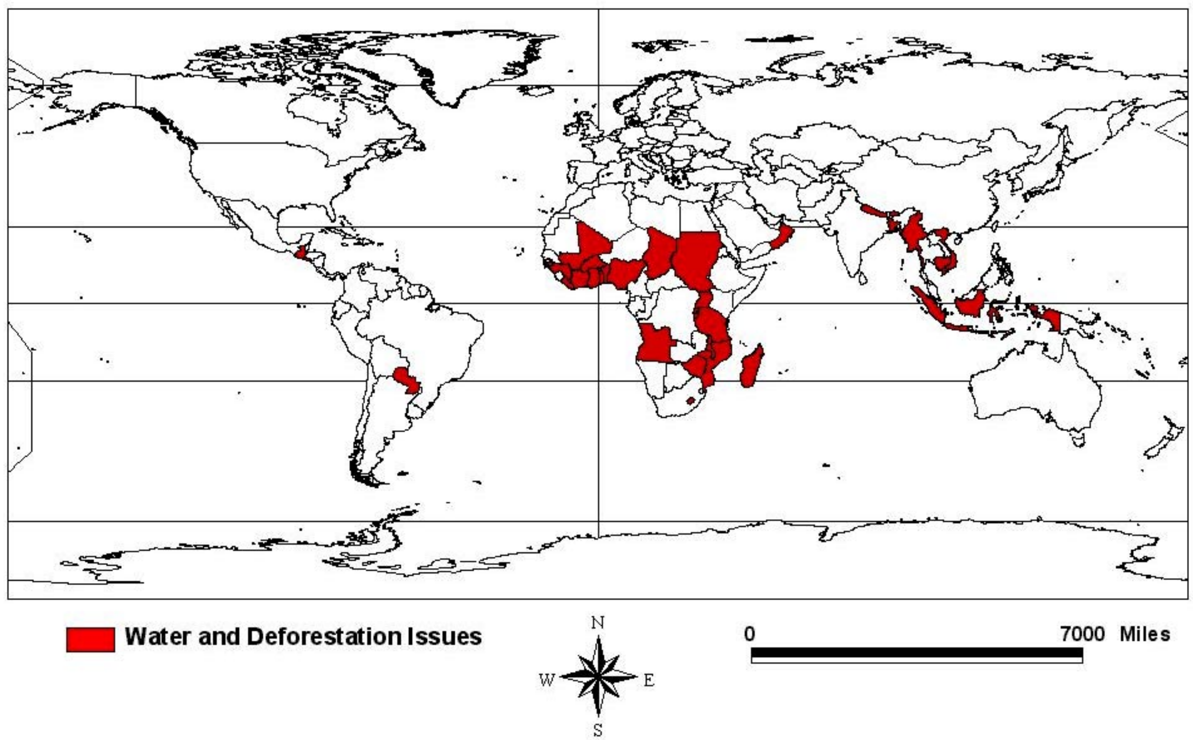


FIGURE 4 – 7

Countries with High Population Growth Rate, Water Scarcity, and Deforestation



shown. Ethiopia, for example, has lost nearly all of its forests over the last 50 years, and therefore is not shown in red in the figure. The Sahel region of Africa (see Figure 3-9, page 41), the Ganges River basin, and the tropical islands of Southeast Asia are the areas of the world most impacted by these resource scarcities and high population growth rates.

Constructing GIS maps for the impacts of global warming is, in the view of this researcher, too problematic to be useful. However, it is possible to identify concerns in a generic way. The most important issue related to global warming is the problem of sea level rise, because most of the world's population lives close to or on a coast. Any loss of land is certain to displace people, in numbers depending on the magnitude of sea rise. Particularly sensitive are the low-lying delta regions around the world that support large populations, such as the Ganges and Nile River area. A small sea rise in these areas will produce measurable to catastrophic harm.

Changes in weather and regional climate are the toughest to predict, temporally or spatially. If Houghton's predictions of climate change shown in Figure 3-9 are considered with the data presented in Figures 4-5, 4-6, and 4-7, there is some basis for discussion, but the information is too inexact to allow for useful predictive models. Nevertheless, the northern belt of the sub-Sahara is clearly the area of greatest concern. It fails to provide basic requirements for a population growing at high rates. The region encompassing east India and Bangladesh is another very resource-limited area where adverse weather and/or sea rise could produce traumatic impacts. Existing monsoon conditions already make catastrophic death from flooding almost routine in this area. Caution should be applied in conducting any sort of analysis based on climate modeling, yet it can be assumed with relative certainty that adverse impacts will be better ameliorated in the developed-temperate north than in the tropical and southern temperate countries.

The data does support making several observations about the environmental security impacts of other issues discussed in Chapter 3, specifically desertification, hazardous wastes, and oceans. As is evident in Table 4-1, most of these environmental issues are more regional than global in their impacts.

Desertification impacts occur in the regions on the margins of existing deserts. These impacts, while extreme for the populations affected, tend to occur in the less populated areas of the world because of the already low carrying capacity of deserts. Waste disposal is of concern primarily because of localized secondary impacts on water quality, but there are regions of the world where environmental exposures to hazardous wastes are producing acute and chronic illness. Parts of the former Soviet eastern block have particularly severe environmental health problems. The world's oceans are being affected by overfish-

ing; a reduction of fish production has been a secondary response to anthropogenic damage to the world's estuaries as a result of water pollution.

In this section we have summarized the impacts of environmental degradation. Since many of the impacts are regionally specific while the data consist of broad, global observations, the methodology presented here is as important as the reported results. The hope is that this type of methodology can be used by regional Commanders in Chief (CINCs) in collecting and applying detailed data from their areas of operation to develop their specific plans.

4.2 Strategic Assessment of Environmental Security as a Military Mission

The fundamental tenet of military power is summed up in the introduction to the National Military Strategy: "The military is a complementary element of national power that stands with the other instruments wielded by our government."[8] The Chairman of the Joint Chiefs of Staff more powerfully expressed the same thought when he stated, "The military is a great hammer, but not every problem is a nail."[9] Since this is the fundamental principle to which we will adhere in conducting our strategic military assessment, is is important to differentiate between the military and non-military environmental security missions of the National Security Strategy.

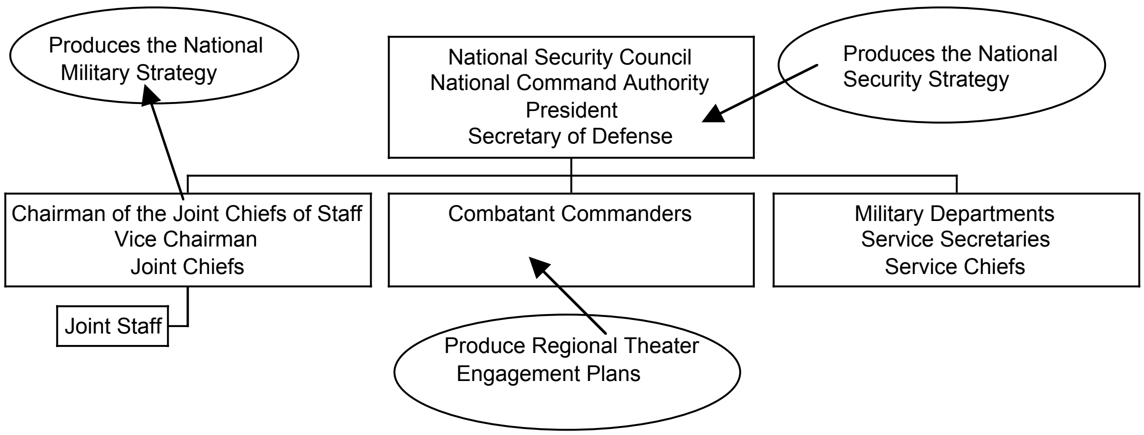
The current framework for developing and implementing U.S. national security policy is represented in Figure 4-8. The National Security Strategy (NSS) is the primary document promulgated by the National Security Council. The National Military Strategy (NMS) is the accompanying policy document promulgated by the Chairman of the Joint Chiefs of Staff.

In the view of this author, the process depicted in Figure 4-8 works well for NSS policy and strategies that relate to wholly military functions, but is inadequate for policy and strategies relating to broad-based, comprehensive issues, such as the nation's environmental security mission. Accomplishing the total environmental security mission requires actions from many departments and offices outside the Department of Defense (DOD), with the bulk of the requirements falling outside the military sphere. Because the requirements for international environmental security are not primarily military, but fundamentally a policy matter

[8] Chairman of the Joint Chiefs of Staff, *National Military Strategy* (Washington, D.C., 1997), 1.
[9] GEN Hugh Shelton, lecture given at the Naval War College, May 2000.

FIGURE 4 – 8

National Security Structure



SOURCE: National Security Decision Making Department, Naval War College, 1999.

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for the Department of State, the DOD should play a supporting role in developing a strategy and executing the environmental security plan.

Figure 4-9 diagrams a proposed governmental structure for environmental security. The structure involves a variety of organizations, indicating both recognition of environmental security as a component of their mission and an existing capability to support this mission. It is evident that no one organization contains all the capability required for developing and implementing a coherent international environmental security strategy. It is equally clear that someone must be in charge, and the nature of the problem suggests this should be the Department of State. Establishment by the Department of State of several regional Environmental Hubs throughout the world shows some recognition of this fact.

Details on the operational requirements of a scheme such as that depicted in Figure 4-9 are well beyond the scope of this study, which remains focused on the DOD activities and functions. This research did not examine State Department activities in support of environmental security, but an interview with Mr. Gary Vest, the Principal Under Secretary of Defense for Environmental Security, indicated that no real plan has been developed by the Department of State, nor has it assumed leadership and management for an overall program.[10]

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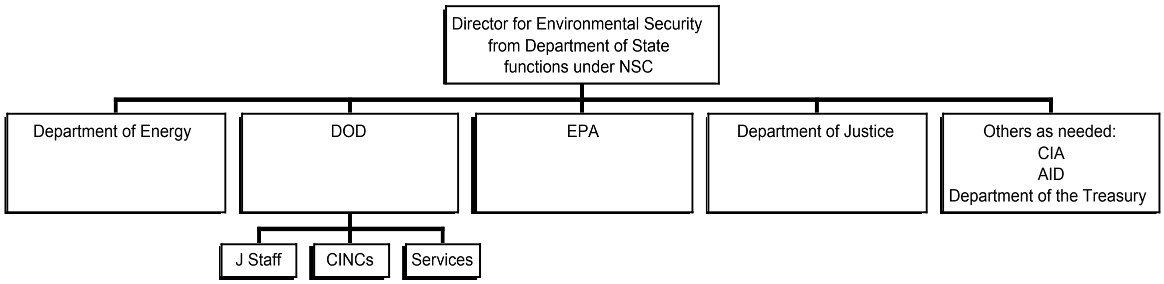
[10] Gary Vest, interview conducted by author 31 March 2000, at the Pentagon.

FIGURE 4 – 9

A Proposed Environmental Security Organizational Structure



- The Director is a senior official from the Department of State, working as part of the National Security Council staff
- Each subordinate organization has a member on the Environmental Security Planning and Review Board

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In the scheme proposed here, it appears logical that any issues primarily of global focus must be managed from the top of the structure, by the Department of State. Global warming, greenhouse gas reduction, and ozone depletion are examples of issues falling into this category. Based on both the data in Table 4-1 and the technical explanations presented in Chapter 3, these are issues that must be addressed with the tools of diplomacy such as international/bilateral agreements and economic diplomacy. The international effort to control ozone-depleting substances is a good example of the effectiveness of this process. As noted earlier, chlorine in the atmosphere is being reduced, directly because of the international cooperation achieved through the Montreal Protocol of 1987.

Protection of the oceans is also primarily a matter of diplomacy, but one which could be aided by supporting uses of the military, particularly the Navy and the Coast Guard. Waste disposal is another primarily diplomatic and legal activity requiring little military support, although the Army Corps of Engineers possesses technical expertise that could aid developing countries in civil works activities.

Land use and surface water issues are the areas where the military can have the greatest utility in a supporting role. The next section of this report will examine some of the ways in which military capability can forward the cause of security in a preventive defense manner.

4.3 Strategic Military Environmental Security Planning

The military approach to accomplishing the National Security Strategy is reflected in the National Military Strategy as “Shape, Respond, Prepare Now.

- “Shape” involves promoting regional stability and preventing/reducing conflict and threats, primarily through actions that can prevent or, as much as possible, mitigate adverse impacts of environmental change. *This is the primary focus of environmental security as it is defined in this paper.*

- In terms of international environmental security, “Respond” entails smaller scale contingency operations where it has been determined that military capabilities are necessary to respond to an environmental security emergency; U.S. actions in Rwanda and Hurricane Mitch are examples of this type of response action. Military response is appropriate when it expedites reestablishment of peace and security in a region or is essential to reduce human suffering.

- “Prepare Now” involves manning, equipping, and resourcing for the missions of the future.

The final issue to be raised in this analysis has to do with the emerging environmental security mission. What should this mission be? The DOD has an office to manage its environmental security program, but this office functions in the context of the program-oriented definition of environmental security found in the DOD directive (see section 2.1), and thus is limited in the attention devoted to the aspects of international environmental security as it is defined in this work. Further, this analysis has shown that most environmental security issues that could involve the military occur at the regional level; this means that primary activities will fall under the purview of the regional CINCs. “Shape” will be addressed in the CINC theater engagement planning (TEP) process and “Respond” will be part of CINC operational contingency planning. It is hoped that CINCs will use the concepts in this document to refine these components of their mission planning and execution.

The Army Center for Strategic Leadership has been a focal point for analysis of environmental security issues as they relate to the DOD and has assisted CINCs in developing environmental security components of their theater engagement plans.[11] “Prepare Now” must begin at the national policy level with a plan that can then be supported by the DOD through

[11] A number of documents from the Strategic Studies Institute, Army War College, many authored by Dr. Kent Butts, are included in the bibliography as general references that enhanced this research.

a structure such as that proposed in Figure 4-9. Until that overarching plan is developed, the DOD does not have the guidance it needs to begin carrying out its supporting roles.

This leads us to the question that drives right to the heart of the matter of environmental security within the DOD: what actions can be taken by the military to help secure peace? Table 4-2 presents a list of ideas compiled from the literature and gathering of information from those with practical experience.

All of the regional CINCs currently conduct military-to-military exchanges. TEP environmental security activities are based on the limited data available to the CINCs, the existing capabilities within the control of the CINCs, and financial constraints. Costs relating to environmental security activities are not identified as separate budget items but receive funding only as part of the general military-to-military engagement strategy intended to "win friends and influence people."

New plans relating to "Shape" should focus on the kinds of functions listed in Table 4-2, with regional analysis refining the priorities for each particular CINC. National resources, such as Corps of Engineers water resource managers, should be made available to aid regional CINCs. Non-DOD experts in critical skills should also be made available through the general environmental security project office. Military-unique issues such as weapons disposal and "green" training should be areas of special DOD attention and effort because they offer an opportunity for both environmental security actions and building cooperative relationships with other militaries.

With regard to "Respond," the sequence of events following a man-made or natural disaster is predictable and, therefore, can be planned for. The overall planning process needs to take place at the DOD level to reduce duplication of effort and ensure optimal use of resources, while execution must be planned at the CINC level. There is now an extensive database from several response actions taken over the last ten years that can serve as a foundation for developing future plans. Personal experience and review of the most recent deployments suggest that the DOD continues to struggle with the same start-up problems and repetitive mistakes. Findings reported by this author in 1994 after the Rwanda mission were similar to reports from Central America after the most recent hurricanes.

"Prepare Now" requires an impetus from the highest levels of government. A mission based on the risks described in this work and substantiated by many others, including the current Vice President, must be developed and resourced. A national level policy and strategy must be developed before military planning can proceed. The process needs to begin with collecting intelligence on issues and areas of concern. This research finds that monitoring of the rate of natural population increase in countries may forecast the potential for environmental

TABLE 4 – 2

Military Environmental Security Missions

In the format of the National Security Strategy of 1997:

Shape:

- Military to military exchanges
  - ◊ Land use planning
  - ◊ Green training
  - ◊ Green use of troops
    - Construction of water and sanitation facilities
    - Construction of solid waste disposal systems
    - Preventive medicine and disease control
  - ◊ Educational programs
- Water Resource Management (Army Corps of Engineers)
- Environmental security intelligence gathering
- Disease surveillance
- Military-unique environmental protection measures
  - ◊ Chemical weapons disposal
  - ◊ Demining
  - ◊ Explosive waste management
  - ◊ Training lands management
  - ◊ Green training

Respond:

- Response-planning standing Tiger Teams formed
- Operational planning for refugee response actions
- Planning for natural environmental disasters
- Enforcement of international environmental laws
- Operational planning for eco-terrorism

Prepare Now:

- Participation in the development of a national environmental security strategy
- Development of DOD policy and strategy for environmental security to complement the national strategy
- Preparation of risk assessment for critical environmental degradation and scarcity issues.

degradation; such data are currently readily available. It is worth noting that the trouble areas predicted on the basis of this model are very much the same as the hot zones identified by James Lee in *Inventory of Conflict and Environment*.[12]

Given a clear mission, and with the other elements of "Prepare Now" listed in Table 4-2 in place, the military can effectively accomplish what should be the military component of an overall environmental security program for the United States.

[12] Lee, 110-111.

5. CONCLUSIONS AND RECOMMENDATIONS

As a career Army officer with 28 years of service and an environmental scientist/engineer now teaching at the United States Military Academy, I chose to research the military implications of environmental security because I felt I could bring to the study a joint military/scientific perspective. It is from this perspective that I present the following observations and recommendations.

At the beginning of this paper it was stated that, because of the destabilizing potential that environmental problems represent in the world, environmental security must be a component of U.S. national security strategy. Among the reasons given for U.S. involvement were the moral obligation this country has incurred because of its high demand for resources and the fact that environmental protection is part of the American ethos. A clean, well-sustained natural environment is one component of the heritage we Americans enjoy and should preserve in perpetuity. However, isolationism in environmental protection is not achievable; it is not possible to separate our air from theirs, our water from theirs, or our health from "their diseases." Unfettered human activities can damage our environment on a global scale. This has been demonstrated as environmental issues have evolved from potential risks to damage control. The depletion of stratospheric ozone is a case in point.

Ozone depletion is used as an example here because it represents hope as well as concern. Once the problem was recognized, science was brought to bear in developing alternatives for fluorinated hydrocarbons. The international community was able to reach agreements for phasing out the use of these compounds. As discussed earlier in this paper, a turnaround in the concentrations of atmospheric chlorine has been achieved and a full recovery of the ozone layer can be predicted.

I remain hopeful that we can, as a country, lead the rest of the world into fruitful discussions on protecting the environment and then set a positive example by practicing what we preach in sustainable development. As a military officer and as a scientist, I see this as the most important element in preventive defense that we can pursue.

International environmental security, as defined in this research, is fundamentally concerned with avoiding conflict. Most who study the causes of conflict agree that conflict requires a set of conditions where people lack or perceive a lack of fundamental requirements to sustain their way of life. In the most basic form, this may be a lack of water, food, shelter,

health, or a sense of security. Only after such basic requirements are in place can cultural and political factors come into play to affect security.

Even lacking these "basic requirements," however, people do not always engage in conflict. Usually some initiating event is required to foment conflict. In the context of this study, the driving force may be natural or human-induced environmental disasters, migration of environmental refugees, or any number of other environmental degradation events threatening basic human health. Let us look at some concrete examples.

Consider Ethiopia, Eritrea, and particularly Somalia, and their continuing state of human suffering and war. The data show that this region has one of the higher rates of population natural increase in the world, has deforested until its fuel wood is almost gone, and is not able to provide sufficient safe water to its people. Although there are cultural conflicts in the region, it is clear that a lack of basic human necessities is a major source of regional insecurity. In pragmatic terms, occasional shipments of food, water, and medicine into this region will never resolve the situation, because these band-aids fail to address the root problem of the regional carrying capacity being outstripped by the population demands.

One other example that is much closer to home is Haiti. U.S. intervention was necessitated by political unrest in that country, but many knowledgeable people have identified the root causes of conflict in Haiti as environmental scarcity and degradation issues. Haiti has limited water supplies and can provide only 30 liters of water per person per day. It is completely deforested, has poor sanitation, and is a densely populated country with a moderate rate of natural population increase. There is no worse set of environmental scarcity and degradation conditions anywhere in the world. The U.S. military entered Haiti to restore security, an impossible task in a country suffering under such environmental conditions. The result was that U.S. had to struggle to extract its military from the continuing chaos.

To this author, the only unknown in the cause-effect relationship of conflict and environmental issues is the size of initiating charge required to set off the time bomb. In a 1999 report entitled *Environmental Conditions, Resources, and Conflicts*, the United Nations listed 20 locations it sees as having the potential for "international conflicts over water."[1] If we look at Sierra Leone, Nigeria, East Timor, Ethiopia/Eritrea, and most of the other areas experiencing conflict in the world today, we find primary or secondary environmental scarcity issues inexorably linked to each conflict. In summary, common sense, natural science, and political science rarely come together so closely as they do in the conclusion that environmental security is a topic of critical importance to the well-being and security of the U.S.

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[1] Daniel Schwartz and Ashbindu Singh, *Environmental Conditions, Resources, and Conflicts* (United Nations Environmental Program, 1999), 11.

5.1 Where Have We Been?

This paper began by presenting an overview of the political science of environmental security. Analysis of the reasons for U.S. involvement was followed by a brief discussion of National Security Strategy and National Military Strategy.

Chapter 2 addressed the problem of defining "environmental security" and proposed the following definition for the term as used in this paper: Environmental security is a process for responding, as part of the U.S. National Security Strategy, to those environmental issues having the potential to affect U.S. national security.

One of the goals of this work was to provide an environmental security primer. This was accomplished in Chapter 3, where the scientific basis for key environmental issues was discussed in lay terms. Chapter 4 presented a strategic analysis of these issues, followed by a discussion of the environmental security mission and of the military's role in that mission.

The list of environmental pollution and degradation issues presented in Chapter 3 is not exhaustive; there are also many other environmental problems facing the world today. Commanders in Chief (CINCs) may find that one of the issues not addressed here is a threat to security in their area of responsibility. The analytic methodology applied in Chapter 4 can be used as a model for collecting and analyzing data and assessing their significance to regional security and stability. With this information, CINCs can draw conclusions as to what specific military action can be taken to support a national strategy for environmental security.

5.2 What Have We Learned?

Having considered the two key questions—

What is environmental security?

What is the military mission in environmental security and how should the mission be executed?

—we can at this point summarize certain observations with regard to the national security implications of environmental issues:

- Environmental security is an ill-defined term that means different things to different groups of people. The Department of Defense (DOD) definition found in DOD Directive 4715.1, which is primarily a broad list of environmentally related programs, is the least precise of all definitions examined. If the military is ever going to address the real security issues caused by environmental change, the DOD directive must be changed to add focus and clarity.

- International environmental security is primarily a diplomatic and political function of the Department of State.

- There is at present no governmental structure for addressing the environmental security requirements of the National Security Strategy (NSS).

- The military environmental security mission, as described in the National Military Strategy (NMS), is to support the NSS and complement the national environmental security strategy.

- The fundamental environmental security issues are environmental resource scarcity and degradation. Critical resources are croplands, forests, water, and fish.

- Population is the controlling independent variable for all environmental security issues. Rate of natural increase is a good measure for correlating environmental impacts and areas of concern.

- The DOD can undertake meaningful international environmental security missions in support of overall U.S. environmental security strategy.

- Geographic areas of greatest concern in terms of environmental security are: the Sahel and central regions of Africa; the island nations of the western Pacific; the East India/Bangladesh region; and the more isolated areas of Central and South America. These regions are highlighted in Figure 5-1, which depicts CINC areas of responsibility.

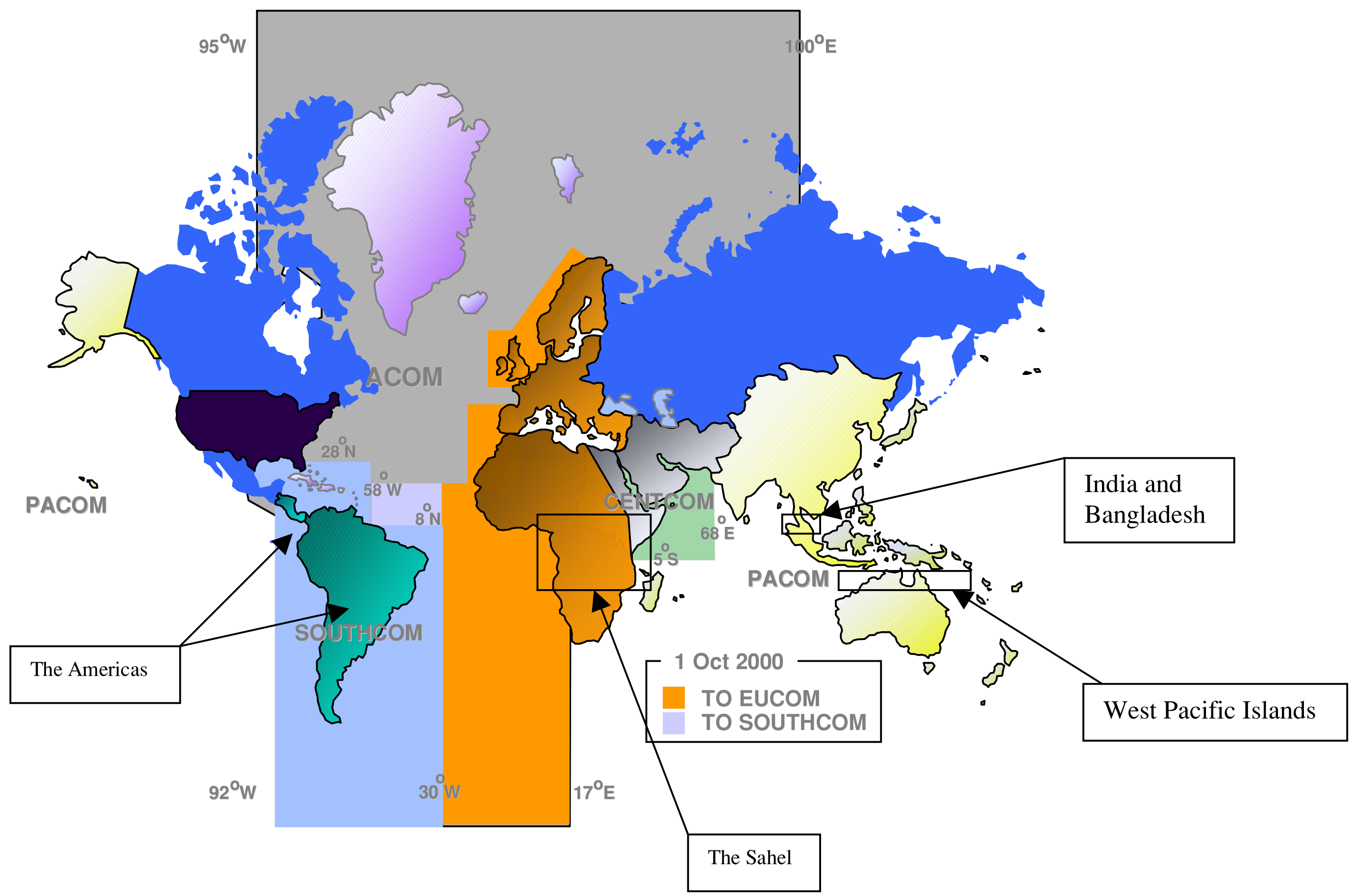
5.3 What Should We Do?

- A national environmental security strategic policy and strategy must be in place before real progress can occur.

FIGURE 5 – 1

CINC Areas of Responsibility

(effective 1 October 2000)



- A governmental structure supported by adequate resources must be set up to develop and implement the goals of U.S. environmental security.

- Existing environmental expertise throughout the government needs to be better utilized. There is tremendous untapped technical power within the Departments of Energy, the Interior, Health, and Defense that could be brought to bear on environmental security matters in a productive and cost effective way.

- DOD Directive 4715.1 needs to be rewritten to define environmental security more precisely. This definition, while having some relation to non-DOD definitions of the term, should serve as a foundation for developing military policy and strategy to meet the NMS missions of environmental security.

- Within the DOD, the environmental security mission must compete for resources. A risk-based analysis that identifies and quantifies the value added by the environmental security program should be conducted.

- The Theater Engagement Plan (TEP) process is the appropriate vehicle for carrying out the military international environmental security program. The Manual for Theater Engagement Planning[2] should be updated to reflect the fact that regional environmental security is a mission component. A program to support the geographic CINCs in developing and implementing the environmental security aspects of the TEP is also needed. The Army War College has made a great start in providing this type of support, but a DOD-wide program needs to be formally instituted. The analytical model used in this research and employed in global analysis provides a useful starting point for detailed regional environmental security assessments.

[2] Chairman of the Joint Chiefs of Staff, Manual (CJCSM 3113.01), Theater Engagement Planning, 1998.

5.4 Final Questions

Does national security policy require any environmental response actions that should become new missions for our military forces?

Certainly there are areas in which the unique capabilities of the military suggest such missions. The gathering of intelligence information through the use of remote sensing technologies is just one example. Although civilian research into data gathering for environmental applications is a fast-developing field, the fact that network centric battlefield information systems could collect valuable environmental data suggests that the military should consider this as a new mission. Such a mission would require additional resources, because environmental security activities should not replace existing military intelligence collection activities. The monitoring of critical environmental resources and agreements is an example of an area in which the current policy of maintaining a forward presence in critical regions could be combined with new missions in international environmental security. Other examples of new missions may emerge as policy and strategy take shape.

Finally, it is appropriate to end this study with probably the most intriguing question for environmental security,

What in the world (environment) is worth (America) fighting for?

Are the Amazon rainforests with their biodiversity and ability to mitigate global climate change worth the use of military power to protect? What about threats to the world's critical water resources? Or threats to the supplies of oil we need to fuel our economy—even at the cost of affecting the global climate?

Today, these and many other questions remain in the "too hard" category of our strategic national policies—too hard because of a lack of certainty, of definite numbers to quantify future impacts of environmental change on U.S. security.

I remain both an optimist and a realist on this subject. We human beings, with our powerful technology, have the capability to irreversibly change the nature of the entire planet, for better or worse. The optimist remains convinced that science and technology will provide the data needed to further our understanding of the earth's processes and with this information we will decide to act to achieve a sustainable environment. The realist recognizes that change will be necessary, that significant costs will have to be paid,

but that these costs will be cheaper than the costs of not addressing environmental security, soon.

We have the technological power to do great harm or great good in the world. Only by proactively pursuing actions to achieve great good will we be able to avoid great harm.

APPENDIX A

Inside the Numbers

Unit of Measure	English Units	Metric Units	Example Areas
Acre	43,560 sq. feet	0.405 hectares	About one foot-ball field
Hectare	2.47 acres	10,000 sq. meters	About two soccer fields
Square mile	640 acres (1 section)	2.59 sq. kilometers	A farm
Square kilometer	247 acres	100 hectares	A small farm
Cubic meter	264 gallons	1,000 liters	A big box
Cubic kilometer	2.64×10^{11} gallons	1×10^{9} M^{3}	100 days of water for New York City

APPENDIX B

Terms and Abbreviations

TERM	DEFINITION
AAEE	American Academy of Environmental Engineers
AEPI	Army Environmental Policy Institute
^oC	Temperature measured on the Centigrade
Carrying capacity	Total population that the resources of an area can support over an indefinite period of time
Centimeter	One hundredth of a meter
CFCs	Chlorinated fluorocarbons
CO	Carbon monoxide
CO_2	Carbon dioxide
DOD	Department of Defense
DOE	Department of Energy
DOS	Department of State
CINC	Commander in Chief
FAO	Food and Agriculture Organization of the United Nations
FGS	Federal Governing Standards
GHG	Greenhouse gases (carbon dioxide, ozone, CFCs, nitrous oxide)
Gigatonne	One billion metric tonnes (a tonne = 2,200 English pounds)
GIS	Geographic Information Systems
IDLH	Immediately Dangerous to Life and Health
Infrared	Long wavelength energy, heat
IPCC	Intergovernmental Panel on Climate Change
km^3	Cubic kilometers
Liter/per/d	Liters per person per day

TERM	DEFINITION
M^3	Cubic meters
mg	Milligrams, one thousandth of a gram
Micrometer	One millionth part of a meter
MMTCE	Million metric tons carbon emissions
NATO	North Atlantic Treaty Organization
NIOSH	National Institute of Occupational Safety and Health
NMS	National Military Strategy document
NSS	National Security Strategy document
PCBs	Polychlorinated biphenyls
PPM	Parts per million, in volume for gases and by weight for solids
TEP	Theater engagement plan
UV	Ultraviolet (shorthort wavelength energy) light
USEPA	United States Environmental Protection Agency
Wavelength	Length of the spacing between peaks of an energy wave
WHO	World Health Organization

BIBLIOGRAPHY

Published Works Cited

Brown, Lester, and Hal Kane. *Full House: Reassessing the Earth's Carrying Capacity*. New York: Norton, 1994.

de Nevers, Noel. *Air Pollution Control Engineering.* Boston: McGraw-Hill, 2000.

Dzurik, Andrew. *Water Resources Planning.* Savage, Md.: Rowman & Littlefield, 1990.

Fetter, C. W. *Contaminant Hydrogeology.* New York: Macmillan, 1993.

Getis, Arthur, and others. *Introduction to Geography.* Boston: McGraw-Hill, 1998.

Gleick, Peter. *The World's Water.* Washington, D.C.: Island Press, 1998.

Glenn, Jerome, and others. *Defining Environmental Security: Implications for the U.S. Army.* Atlanta, Ga.: AEPI, 1998.

Goode's World Atlas. Edited by Edward Espenshade and others. New York: Rand McNally, 1995.

Gore, Albert. *Earth in Balance.* Boston: Houghton-Mifflin, 1992.

Horel, John, and Jack Geisler. *Global Environmental Change: An Atmospheric Perspective.* New York: John Wiley, 1997.

Homer-Dixon, Thomas. *Environmental Scarcity and Global Security.* New York: Foreign Policy Association, 1993.

Houghton, John. *Global Warming: The Complete Briefing.* Oxford, England: Lion Publ., 1994.

Huntington, Samuel. *The Clash of Civilizations and the Remaking of the World Order.* New York: Simon and Schuster, 1996.

King, W. Christopher. *Environmental Engineering: P.E. Examination Guide and Handbook.* Annapolis, Md.: AAEE, 1996.

Lee, James. *Inventory of Conflict and Environment.* Atlanta, Ga.: AEPI, April 1999.

MacKenzie, Fred T. *Our Changing Planet.* New Jersey: Prentice Hall, 1998.

National Institute of Occupational Safety and Health (NIOSH). *Pocket Guide to Chemical Hazards.* Washington, D.C.: U.S. Public Health Service, 1990.

Myers, Norman. "The Environmental Dimension to Security Issues." *The Environmentalist* (1986): 251-57.

———. *Ultimate Security: The Environmental Basis of Political Stability.* New York: Norton, 1993.

Schwartz, Daniel, and Ashbindu Singh. *Environmental Conditions, Resources, and Conflicts.* United Nations Environment Programme, 1999.

Simon, Paul. *Tapped Out—The Coming World Crisis in Water and What We Can Do about It.* Champaign, Ill.: Welcome Rain Publishing, 1998.

Strahler, Alan, and Arthur Strahler. *Introducing Physical Geography.* New York: John Wiley, 2000.

Titus, James, and Vijay Narayanan. *The Probability of Sea Level Rise.* Washington, D.C.: USEPA, 1995.

White, Rodney. *North, South, and the Environmental Crisis.* Toronto: University of Toronto Press, 1993.

U.S. Environmental Protection Agency (USEPA). Website: www.epa.gov/globalwarming/emissions/international/inventories.html, April 2000.

———. Website: www.epa.gov/globalwarming/publications/reference/ipcc/summary/page4.html, April 2000.

Reports and Papers Cited

Chairman, Joint Chiefs of Staff. *National Military Strategy.* Washington, D.C., 1997.

Department of Defense (DOD) Directive. SUBJECT: *Environmental Security* (Number 4715.1, February 1996).

Food and Agriculture Organization of the United Nations (FAO). *Forest Resources Assessment 1990: Global Synthesis.* As reported at: www.igc.apc.org/wri/wr-96-97/lc_ttxt2.html, April 2000.

Intergovernmental Panel on Climate Change (IPCC). *Climate Change 1992: The Supplemental Report to the IPCC Scientific Assessment.* Geneva: United Nations, 1992.

U.S. Environmental Protection Agency (USEPA). *Environmental Security* (USEPA 160-F99-001). Washington, D.C., 1999.

Vest, Gary, "DOD International Environmental Activities." *Federal Facilities Journal* (Spring 1997): 8.

The White House *A National Security Strategy for a New Century.* Washington, D.C., 1999.

World Health Organization (WHO). *Community Water Supply and Sanitation: Needs, Challenges and Health Objectives* (A48/EOS/96.15). Geneva: 48th World Health Assembly, 1995.

World Resources 1996-1997. Website: www.igc.apc.org/wri/wr-96-97, April 2000.

Non-published Works Cited

Armitage, Ambassador Richard. Lecture at the Naval War College, May 2000.

Brodie, Bernard. "The Worth of Principles of War," from a lecture delivered on 7 March 1957 at the U.S. Army Command and General Staff College, Fort Leavenworth, Kans.

Chairman of the Joint Chiefs of Staff. Manual (CJCS A 3113.01), Theater Engagement Planning, 1998.

Claussen, Eileen. Speech given at the International Conference on Climate Change, Washington, D.C., July 1994.

Danzig, Richard, Secretary of the Navy. Lecture given at the Naval War College, June 2000.

Russian Academy of Science member. Lecture given at the United States Military Academy, 1994.

Shelton, Hugh, GEN. Lecture given at the Naval War College, May 2000.

Vest, Gary. Interview conducted by COL King, 31 March 2000, at the Pentagon.

Works Reviewed

Berner, Elizabeth, and Robert A. Berner. *Global Environment.* New Jersey: Prentice Hall, 1996.

Butts, Kent. "Environmental Security: A DOD Partnership for Peace." Strategic Studies Institute, U.S. Army War College, 1994.

———. "Environmental Security: What is DOD's Role?" Strategic Studies Institute, U.S. Army War College, 1993.

———. “NATO Contributions to Environmental Security.” Strategic Studies Institute, U.S. Army War College, 1993.

Environmental Change and Security Project Reports 1–4. Woodrow Wilson International Center for Scholars. http://ecsp.si.edu/ecsplib.nsf/report, May 222, 2000.

Feagle, Robert. *Global Environmental Change.* Westport, Conn.: Praeger, 1994.

Lietzmann, Kurt, and Gary Vest. “Environment and Security in an International Context,” NATO Report No. 232, 1999.

Pojman, Louis. *Global Environmental Ethics.* Mountain View, Calif.: Mayfield Publ., 2000.